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BIOMECHANICAL FIELD STUDY OF SLALOM TURN DURING SECOND RUN SNOW QUEEN TROPHY RACE

Cigrovski Vjekoslav, Antekolović Ljubomir, Zadravec Mateja, Bon Ivan
University of Zagreb, Faculty of Kinesiology

Abstract

Slalom is a challenging alpine ski discipline from both tactical and technical perspective. Biomechanical factors influence the tactics employed during the race and can affect success. We performed biomechanical field study investigating velocity at different sections of slalom turn, angles of lower extremity during turn performance and their relation to projection of centre of mass during FIS World Cup Race Snow Queen Trophy. Kinematic analysis of slalom turn was performed to compare the correlations between angles in joints of lower extremities, distance of centre of mass during different segments of turn and velocity of skiing during turn in competitor level skiers. The Ariel Performance Analysis System was used to calculate the 3D kinematic data for 30 elite alpine skiers participating in the second run. Results suggest highest variability between competitors in velocities achieved during turn initiation. Moreover, we found correlation between competitors' velocity during turn initiation and angle in the knee joint (r=0,56). Additionally, velocity during initial phases of turn correlated with centre of mass with respect to inner ankle joint (r=0,63), as well as with outer ankle joint (r=0,58). Moreover, angles between upper and lower leg correlated significantly with velocity during all phases of slalom turn, while we found no correlation whatsoever between competitors' upper leg and core and velocity. Significant correlation was also seen between velocity during all three phases of ski turn and centre of mass during middle part of the turn in relation to both inner and outer ankle joint. Our data suggest that competitors with lower velocity at the beginning of the turn opted for a less direct trajectory. But due to configurational differences and different ways gates are positioned through entire race, competitor is not able to use the same tactics through an entire slalom race, so velocity over one turn might not have an overwhelming influence on the velocity of the race in a whole. To conclude, many different biomechanical factors influence the performance during slalom race and competitor must take into account intricate interactions between them under different conditions to minimize the descent time.

Key words: *slalom, kinematic, velocity of skiing, line of skiing, skiing technic*

Introduction

The difference between medal winning places in highly competitive slalom discipline of alpine skiing is often measured in fractions of a second. These small winning margins accentuate the need for a better understanding of factors influencing performance. Biomechanics of slalom skiing imposes as an important field of investigation (Hebert-Losier et al., 2014). Racing tactics that current elite alpine skiers apply relates to the choosing of specific trajectory while passing through the gates. Choosing the right trajectory enables reaching higher velocities or keeping the existing speed of skiing (Cigrovski & Matković, 2015). To shorten the route between the gates, competitors on the steep parts often choose direct trajectory. Mentioned tactics together with alpine ski technique are the main factors underpinning the speed of ski sliding (Federolf et al., 2013). In the recent years, slalom discipline is specific due to more narrow corridor of turns and shortening of the ski arches. This means that competitors are faster and that they have minimized the path between the gates (LeMaster, 2010). Choosing the right moment in which competitor will initiate the new turn or will pass from one turn to another for the consequence has ideal speed of ski sliding and might influence the success of ski performance (Hebert-Losier et at., 2014). That is why each competitor before ski race divides slalom track into several segments and decides on the trajectories while passing through the gates. Supej and Cernigoj (2006) specifically divided alpine ski race track into nine segments and shown how performance of first three competitors differed in ski tactics in all the mentioned ski sections. Because of different tactics in different segments, competitors differ in ski technique and adjust ski technique to the trajectory choice. Differences in ski technique can be followed by observation of competitors' joints and body segments as well as by ski movements during particular stages of the ski turn (Hraski & Hraski, 2009; Reid et al., 2009; Kipp et al., 2010). By analysing the angles in the competitors' joints as well as the projections of the body's centre of gravity in certain parts of the turn, it is likely possible to predict ways of making turns regarding ski techniques and tactics.

Methods

Participants: 30 male professional skiers, mean age 27.12±1.15 years were included in the investigation. They were tested during slalom competition FIS Ski World Cup Snow Queen Trophy (Sljeme, Croatia).

Variables: Kinematic variables that were used to describe slalom turn included: velocity at the beginning of slalom turn (VB), measured time at the beginning of ski turn in ms^{-1}, velocity in the middle part of the slalom turn (VM), measured time during central phase of ski turn in ms^{-1}, velocity at the end of slalom turn (VE), measured time at the end of ski turn in ms^{-1}, knee angle (KA), measures angle between upper and lower leg in °, hip angle (HA), measures angle between upper leg and core in °, centre of mass at the beginning of slalom turn in relation to inner ankle joint (COMIAB), represents the difference between projection of centre of mass at the beginning of the turn and ankle joint of the inner leg measured in cm, centre of mass at the beginning of slalom turn in relation to outer ankle joint (COMOAB), represents the difference between projection of centre of mass during beginning of ski turn in relation to outer leg measured in cm, centre of mass at the middle of the slalom turn in relation to inner ankle joint (COMIAM), represents the difference between projection of centre of mass and inner leg ankle joint measured in cm, centre of mass at the middle of the slalom turn in relation to outer ankle joint (COMOAM), represents the difference between projection of centre of mass and outer leg ankle joint measured in cm, centre of mass at the end of slalom turn in relation to inner ankle joint (COMIAE), represents the difference between projection of centre of mass and inner leg ankle joint measured in cm, centre of mass at the end of slalom turn in relation to outer ankle joint (COMOAE), represents the difference between projection of centre of mass and outer leg ankle joint measured in cm.

Research protocol: We analysed some biomechanical aspects during one slalom turn. Data for kinematic analysis was filmed during slalom competition by two DV cameras (Sony HDR-HC9E), with 50 photos per second and with shutter speed 1/500 sec. The space calibration was done with cube (180 cm x 180 cm x 180 cm) filmed after competition on the position of analysed slalom turn. Position of cameras is shown in Figure 1.

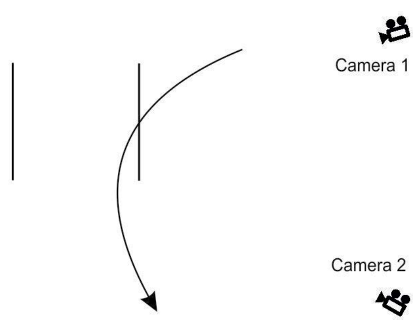

Figure 1. Camera positions

Statistical methods: The Ariel Performance Analysis System (APAS, Ariel Dynamics inc., USA) was used to analyse video recordings and calculate the 3D kinematic data. Correlations between the analysed variables were tested by correlation analysis. The Statistica ver. 7.1 (StatSoft, Inc., 2006) was used. All competitors of the 2nd slalom run were filmed by two DV cameras (Sony HDR-HC9E) operating at 50 fps with shutter speed of 1/500 sec. The space calibration was done with cube (180 cm x 180 cm x 180 cm) filmed after competition on the position of analysed slalom turn.

Results and discussion

Results of the descriptive statistics are presented in Table 1.

Table 1. Descriptive statistics

Variable	N	M	Min	Max	V	SD	a3	a4
VB	30	14,17	9,65	17,93	1,99	1,41	-0,6	5,54
VM	30	13,14	11,4	13,91	0,29	0,53	-1,79	4,17
VE	30	13,1	12,21	14,97	0,27	0,52	1,82	6,7
KA	30	95,13	86,04	104,88	24,6	4,96	-0,09	-0,76
HA	30	91,35	77,4	107,14	74,49	8,63	0,19	-0,91
COMIAB	30	4,5	0,1	19	16,48	4,05	2,13	6,24
COMOAB	30	21,79	9	35	31,12	5,57	0,27	0,9
COMIAM	30	8,47	0,6	16	18,33	4,28	-0,49	-0,57
COMOAM	30	6,52	0,4	15	17,66	4,2	0,24	-0,87
COMIAE	30	-21,33	-32	-4	40,31	6,34	1,2	2,38
COMOAE	30	-15,7	-31	-3	44,3	6,65	-0,12	0,04

Legend: VB-velocity at the beginning of slalom turn; VM velocity in the middle part of the slalom turn; VE-velocity at the end of slalom turn; KA-knee angle; HA-hip angle; COMIAB-centre of mass at the beginning of slalom turn in relation to inner ankle joint; COMOAB-centre of mass at the beginning of slalom turn in relation to outer ankle joint; COMIAM-centre of mass at the middle of the slalom turn in relation to inner ankle joint; COMOAM-centre of mass at the middle of the slalom turn in relation to outer ankle joint; COMIAE- centre of mass at the end of slalom turn in relation to inner ankle joint; COMOAE-centre of mass at the end of slalom turn in relation to outer ankle joint

Correlation analyses are presented in Table 2.

Table 2. Correlation between analysed variables

Variable	VB	VM	VE	KA	HA	COMIAB	COMOAB	COMIAM	COMOAM	COMIAE	COMOAE
VB	1	0,98*	0,97*	0,56*	0,42	0,63*	0,58*	0,64*	0,62*	-0,11	-0,09
VM		1	0,99*	0,53*	0,37	0,54*	0,49	0,58*	0,56*	-0,17	-0,15
VE			1	0,5*	0,32	0,51*	0,42	0,51*	0,5*	-0,21	-0,2
KA				1	0,92*	0,07	0,57*	0,2	0,14	-0,59*	-0,53*
HA					1	0,23	0,77*	0,39	0,39	-0,28	-0,2
COMIAB						1	0,77*	0,94*	0,95*	0,66*	0,67*
COMOAB							1	0,87*	0,83*	0,32	0,39
COMIAM								1	1	0,6*	0,65*
COMOAM									1	0,64*	0,67*
COMIAE										1	0,99*
COMOAE											1

*Legend: VB-velocity at the beginning of slalom turn; VM velocity in the middle part of the slalom turn; VE-velocity at the end of slalom turn; KA-knee angle; HA-hip angle; COMIAB-centre of mass at the beginning of slalom turn in relation to inner ankle joint; COMOAB-centre of mass at the beginning of slalom turn in relation to outer ankle joint; COMIAM-centre of mass at the middle of the slalom turn in relation to inner ankle joint; COMOAM-centre of mass at the middle of the slalom turn in relation to outer ankle joint; COMIAE- centre of mass at the end of slalom turn in relation to inner ankle joint; COMOAE-centre of mass at the end of slalom turn in relation to outer ankle joint; * - significant at p=0.05*

Data suggest variations in velocity at the beginning of slalom turn ranging from 9,65 to 17,93 ms^{-1} (Mean=14,4 ms^{-1}), during middle part of the turn from 11,4 to 13,91 ms^{-1} (Mean=13,4 ms^{-1}), while velocity range during final parts of the slalom turn ranged from 12,21 to 14,97 ms^{-1} (Mean=13,1 ms^{-1}). The greatest variability in competitors' velocity was seen during slalom turn initiation, where the differences between competitors in the filmed segment of slalom turn were greatest. According to Federolf and coworkers, the difference in velocity between competitors persisted all through phases of the slalom turn (2013). Our data suggest that competitors with lower velocity at the beginning of the turn opted for a less direct trajectory. Similar observation was reported by Lešnik and Žvan (2007), where skiing velocity generally increases as the skiing line decreases. In the present investigation, we measured skiers' velocity during three phases of ski turn (during turn initiation, at the middle part and at the end of turn). The greatest correlation was seen between competitors' velocity during turn initiation and angle in the knee joint (r=0,56). Additionally, velocity during initial phases of turn correlated with centre of mass with respect to inner ankle joint (r=0,63), as well as with centre of mass with respect to outer ankle joint (r=0,58). Angles in the knee joint varied between 86° and 104° (Mean=95°), while angles in the hip joint varied between 77° and 107° (Mean=91°). Analysed angles between upper and lower leg correlated significantly with velocity during all phases of slalom turn, while we found no correlation whatsoever between competitors' upper leg and core and velocity. On the contrast, results by Hraski and Hraski (2009) measuring angles between core and angles in different joints suggest that higher angles in the hip joint correlated with higher velocity and better performance during slalom turn. Centre of mass at the initiation of slalom turn varied from 0,1 to 19 cm (Mean 4,5 cm) in relation to inner leg ankle joint, and 9 to 35 cm (Mean 21,7 cm) in relation to outer leg ankle joint. Centre of mass at the middle section of ski turn varied 0,6 to 16 cm (Mean 8,4 cm) in relation to inner ankle joint, and 0,4 to 15 cm (Mean 6,5 cm) in relation to outer leg ankle joint. Centre of mass at the end of the slalom turn varied between-32 to -4 cm, (Mean=-21,3 cm) in relation to inner ankle joint, and between -31 and -3 cm, (Mean=-15,7 cm) in relation to outer leg ankle joint. Significant correlation was seen exclusively between velocity during all three phases of ski turn and centre of mass during middle part of the turn in relation to both inner and outer ankle joint.

Kinematic analysis of slalom turn was performed to compare the correlations between angles in joints of lower extremities, distance of centre of mass during different segments of turn and velocity of skiing during turn in competitor level skiers. This enables analysis of ski technique and tactics relating to choosing different trajectories during ski turns. Mentioned was also analysed in our previous investigation where we found no significant difference between distances between skiers' body from the gate compared to velocity of skiing in the analysed turn (Antekolovic et al., 2015). We can argue that one turn did not have an overwhelming influence on the velocity of the race in a whole. Due to configurational differences and different ways gates are positioned through entire race, competitor is not able to use the same tactics through an entire slalom race. Usually accepted is that maintenance of high velocities is an important determinant of ski performance, regardless of ski trajectory, technique or approach to turn execution (Hebert-Losier et at., 2014). Several studies reported that more rapid turns were initiated further from the gate, and completed closer to the gate and were longer, allowing greater acceleration from the gate and straighter skiing after the gate (Supej, 2008; Sporri et al., 2010). As important are the current snow conditions during race which affect competitors' tactics. All the mentioned suggests that many different biomechanical factors influence the performance during slalom race and that intricate interactions between them and under different conditions must be used by competitor to minimize the descent time. Slalom racing is a complex and challenging discipline from both technical and tactical perspectives. Biomechanical components of slalom turn are important factor in performance of elite competitors and may be one of the determining factors of success. A limitation of this study is analysis of skiing performance over one gate, so generalization of findings must be done with caution to determine whether performance of one turn accurately reflects performance of an elite skier across the series of gates and whether instantaneous performance can be maintained throughout an entire race. But in biomechanical field studies, video-based systems are widely used and considered reliable tools.

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FUNCTIONAL ASSESSMENT OF MOVEMENT WITH THE AIM OF ESTABLISHING ASYMMETRY IN THE RANGE AND QUALITY OF MOTION IN VOLLEYBALL PLAYERS „HAOK MLADOST“

Đurković Tomislav[1], Ivančić Matija[2], Marelić Nenad[1]
[1]Faculty of Kinesiology, University of Zagreb
[2]HAOK Mladost volleyball club

Abstract

Purpose: The main goal of this study is to determine possible asymmetry in the range and quality of movement in senior volleyball players. *Methods*: Respondents were nineteen (n=19) male volleyball players, all right handed, healthy and members of „HAOK Mladost“ (M±SD age 20.1±3.1, height 193.6±6.9; weight 82.4±8.5, with 2 libero players). The testing was conducted during the second week of the preparation period. We used five tests which can indicate asymmetry, all five part of standard FMS protocol (Hurdle Step – HS, In-Line Lunge – ILL, Shoulder Mobility – SM, Active Straight Leg Raise – ASLR, Rotary stability – RS). Educated staff at the Faculty of Kinesiology, University of Zagreb conducted the testing. The examination of significance of the differences between the left and right side of the body was conducted by using the nonparametric ***Wilcoxon Signed Rank***. *Results*: Statistical analysis showed significant difference only in one test: hurdle step (HS), z = - 2.12, p=0.03, with moderate effect size (r=0.34). The results clearly point to the problem of reduced stability of the right leg, reduced mobility of the left leg, and reduced mobility in the left hip joint. *Conclusion*: The cause of asymmetry could be the unilateral technique of landing after offensive and defensive jumps (predominantly left leg for right handed players) which can cause loads that lead to micro traumas, and ultimately, to lower stability and mobility of the entire kinetic chain on the left side of the body. Consecutive single leg landings may occur due to the wrong motion pattern caused by the poor strength of an athlete’s body, inadequate spiking technique (non-symmetric hand swing during the preparation phase of the spike) or inaccurate setting. Considering the obtained results, corrective exercises should be carried out in two directions. The first relates to the development of stability of the right leg and the second to the development of mobility of the left leg and left hip. Adoption and stabilization of proper spiking and setting techniques are implied.

Key words: *volleyball, stability, mobility, FMS*

Introduction

Proper posture, evenly developed strength and flexibility of muscles and joints, and well-developed balance are prerequisites for intensive volleyball trainings. Although volleyball may seem as a sport in which the load during the performance of technical elements appears symmetrical (peak and lower forearm rejection, blocking, defense), such as while performing spike and serve techniques or blocks, previous studies identified patterns which can result in micro traumas that can then lead to postural asymmetry, and eventually to injuries (Kugler et al., 1996; Wang & Cochrane, 2001; Salci et al., 2004; Tillman et al., 2004; Markou & Vagenas, 2006; Lobietti et al., 2010; Čučková & Süss, 2014; Zohreh & Ashraf, 2016; Đurković et al., 2017). Stability and mobility are particularly relevant for the proper performance of technical elements in volleyball. Optimal stability of the shoulder blade as well as mobility of the shoulder and the thoracic spine are prerequisites required for the proper execution of a spike and block. Furthermore, serve reception and defensive play require mobility of the thoracic spine and shoulder as well as stability of the lumbar spine, while in sudden changes of direction and speed of movement stability of the knee and mobility of the joint are of significant importance. Jumping during offensive play and blocking require a mobile iliopsoas muscle and stable knees and trunk during the landing that should be symmetrical – on both feet. Functional Movement Screen – FMS (Cook, 2010) is a diagnostic method used for assessing the stability and mobility of various parts of the body and for determining asymmetry between the left and right side of the body. This methodology was also used for research in all team sports games: volleyball, basketball, soccer and handball (Čučková & Süss, 2014; Shojaedin et al., 2014; Slodownik et al., 2014; Sprague et al., 2014; Đurković et al. 2017). The method was designed as it was considered that classic tests often lacked basic human movements that would allow for more precise determination of possible asymmetries. The protocol includes seven different tests that enable diagnosing limitations in the mobility and stability of examinees as well as various types of asymmetry, such as between the left and right side of the body. The mentioned system can both be applied for professional athletes with the aim of achieving top-level results, as well as for recreational athletes for prevention of injuries. In order to determine stability and mobility, each test is numerically evaluated using grades between zero and 3, which means that an examinee can achieve a maximum result of 21 points. Analysis is first conducted for movements that an athlete is unable to perform, thus the examinee then scores zero points. When scoring 1 point, an athlete does not have a functional base of stability and mobility, indicating that a sports physician should further assess flexibility and strength in more detail. A score of 2 points does not necessarily require an examination by a sports physician, but a physical conditioning coach creates special training programs in order to improve stability and (or) mobility of the desired part of the body. An assessment of 3 points indicates optimal stability and mobility in particular joints.

Methods

Educated personnel at the Faculty of Kinesiology, University of Zagreb conducted the testing. All examinees signed an informed consent form for the implemented measurements. The sample of examinees included 19 men's Premier league volleyball players who are members of the „HAOK Mladost" from Zagreb. All the examinees are right-side dominant players. For the purpose of this research, 5 bilateral tests were used that are part of the FMS screening tool protocol; Hurdle Step – HS, In-Line Lunge – ILL, Shoulder Mobility – SM, Active Straight Leg Raise – ASLR, Rotary stability – RS. Data processing was performed in accordance with the aim of this research so that it referred to establishing central and dispersive indicators of the measured variables, as well as to determining the significance of the differences in the measured variables on the left and right side of the body. The examination of the mentioned significance of the differences in the measured variables on both sides of the body was conducted by using the ***Wilcoxon Signed Rank Test*** for paired samples.

Results

Table 1. Represents the results for descriptive statistical parameters.

Table 1. Descriptive statistical parameters

TEST	SIDE	M	N	SD	SEM
Hurdle step (HS)	Left (L)	1.84	19	0.37	0.09
	Right (R)	2.16	19	0.6	0.14
In-Line Lunge (ILL)	L	2.32	19	0.58	0.13
	R	2.21	19	0.53	0.12
Shoulder Mobility (SM)	L	2.32	19	0.58	0.13
	R	2.58	19	0.51	0.12
Active Straight Leg Raise (ASLR)	L	2.05	19	0.78	0.18
	R	2.26	19	0.65	0.15
Rotary stability (RS)	L	2.00	19	.00	.00
	R	2.00	19	.00	.00

M=arithmetic mean; n=number of examinees; SD=standard deviation; SEM= standard error

Table 2 demonstrated the results of the Wilcoxon Singed Rank Test for the 5 measured variables.

Table 2. Wilcoxon Signed Rank results (differences between right and left side)

	HS_R HS_L	ILL_R ILL_L	MR_R MR_L	ASLR_R ASLR_L	RS_L RS_L
Z	-2.12^b	$-.38^c$	-1.67^b	-1.63^b	-1.00^c
p	***.03****	.70	.09	.10	.31

Z – Z value, p – level of significance, *indicates statistical significance (p <0.05)

Discussion

Table 1 shows a higher numeric difference in results of the In-Line Lunge test (ILL_L and ILL_R) where the arithmetic mean is higher on the right side, which clearly indicates a problem of reduced stability of the right leg, reduced mobility of the left leg, and reduced mobility in the left hip joint. A statistically significant difference in Table 2 appears in only one variable – the In-Line Lunge test (ILL). By using the Wilcoxon Singed Rank Test, a statistically significant difference was determined in the range and quality of movement of the right leg (ILL_R) compared to the left leg (ILL_L), z=- 2.12, p=0.03, with medium level of significance (p=0.34) according to the Cohen criterion, which leads to the conclusion that the right hip is more mobile than the left in the tested volleyball players. The determined asymmetry is presumably caused by unilateral landings on the left leg as all the examinees dominantly use their right hand for spiking. According to the study performed by Tilman et al. (2004) up to 50% of landings after spiking and blocking are unilateral, out of which as much as 35% accounts for landings on the left leg. Such landings can result in micro traumas as the force during the landing movement is only accumulated on one side of the body – the left side. The cause of unilateral landings is most often the lateral flexion of the trunk to the left side during the preparation and basic phase of the spike, particularly when executing spikes from the first line on the left side of the net in zone 4. Consecutive single leg landings may occur due to the wrong motion pattern caused by the poor strength of an athlete's body, inadequate spiking technique (non-symmetric hand swing during the preparation phase of the spike) or inaccurate setting. The mentioned results indicate the relevance of correcting the spiking technique and the landing technique after the spike, as well as the importance of evaluating the trajectory regularity of a passed ball and the potential correction of this trajectory. Great variations in hip mobility can have a negative effect on the lower extremities and increase the possibility of an injury. There is evidence that players with injuries of their jumper's knee have altered landing technique and weaker hip flexors when compared to athletes without such mentioned symptoms (Silva et al., 2015). It is possible to reduce pain in players with patellar tendinopathy, i.e. jumper's knee, following procedures for strengthening of the hip muscle combined with gradual correction of the landing technique. If muscles of the hip and the pelvic ring are not of optimal strength, then the force created in the landing is transferred to the knees and ankles, which significantly increases the risk of injuries. Closed kinetic chain exercises, proprioceptive trainings and trunk stabilisation exercises have a positive effect on neuromuscular control of joints, while also reducing the risk of anterior crucial ligament injuries as well as injuries of other joints of the lower extremities (Linek et al., 2016).

Conclusion

The primary aim of this study as to determine if there are asymmetries in the range and quality of movement in senior volleyball players of „HAOK Mladost". The obtained results demonstrate that there are significant differences in the results of the In-Line Lunge test, indicating asymmetries and imbalance in the hips. The mentioned asymmetries are caused by repeated unilateral landings after offensive (spiking) and defensive (blocking) jumps. Upon consideration of the large number of games played during the season, and thus the number of jumps with the mentioned landings, the possibility for the occurrence of asymmetries in the mentioned part of the body is that much higher. Spiking, as one of the most demanding elements in volleyball, requires optimal technique as well as maximal strength and speed during the execution, in addition to precision of the passer who passes the ball to the hitter. The registered statistically significant asymmetry is a warning for the coaching staff to create and practice corrective exercises that shall annul the imbalances, as well as enable volleyball players to conduct trainings and games without experiencing pain. This corrective program should refer to solving two problems. The first one being the development of stability in the right hip and leg, while the second one is the development of mobility in the left hip and leg. The selection of exercises should integrate stabilisation exercises for the trunk (versions of "glute bridges", versions of split squats) exercises for improving ankle mobility (half kneeling dorsiflexion) exercises for troracic mobility ("T-spine" rotation, "Brettzel") and different exercises for diaphragmatic breathing.

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COMPARISON OF PHYSICAL PREPAREDNESS OF FOOTBALL REFEREES OF DIFFERENT COMPETITION LEVELS

Hruša Petr, Orel Pavel
University of Hradec Králové, Hradec Králové, Czech Republic

Abstract

General physical preparedness plays an important role in motor performance. Coping with the physical loading in games, and thus being able to get close to individual game situations, can be seen as a precondition to judge the game correctly. The aim of the research is to compare physical preparedness of football referees of the selected different competition levels.

42 football referees participated in the study. There were two groups of different competition levels. The first group (n = 17) comprised 3rd league and professional competitions, the other group (n = 25) comprised regional competitions of 1.B and 1.A class. The indicators of physical preparedness were maximal aerobic capacity (VO_{2max}) and shuttle run test. The participants had to run repeatedly 20 metres distance in the given pace. The score is the number of sections, run in the given pace, to exhaustion. Maximal aerobic capacity was measured and processed by means of sport tester of Polar RS800CX and ProTrainer software. The two independent groups were compared in terms of cardiorespiratory endurance indicated by the shuttle run test and VO_{2max}. Statistical significance of difference was evaluated by independent Mann-Whitney U-test ($p<0,05$).

A significant difference ($p<0,05$) was found out in both selected indicators of physical preparedness, which suggests that the performance of referees differed between the selected groups. With regard to different level of football competitions, the referees from 3rd league and professional competitions had both higher maximal aerobic capacity and better performance in the shuttle run test compared to the referees from 1.B and 1.A class. The performance in the shuttle run test was better on average by 1 time segment and the VO_{2max} was better on average by 3 ml/kg.min in 3rd league referees.

The research results support the assumption that the football referees of higher competitions have better level of general physical preparedness. Physical factor is one of the components of motor performance. However, to get a complex idea of factors influencing motor performance, further analysis is recommended in terms of psychological, technical and tactical factors.

***Key words**: referee's performance, physical preparation, VO_{2max}, shuttle run.*

Introduction

Football is a sport game involving contact between the opposing teams, and the referee is an important person to supervise the rules. The match is conducted by the main referee who decides on offenses and goals and two assistant referees to help to decide offside situations, out of bounds, kickoff or corner kick. There are high demands on decision-making regarding physical, mental, tactical and technical preparedness (Perič & Dovalil, 2010), in accordance with the conceptual model of refficacy (Guillén & Feltz, 2011), as shown in Figure 1. Referees are expected to perform impeccably, however, there is a wide range of stressors they have to face. Guillén and Feltz (2011) defined the term „refficacy", which is in fact referee's efficacy. They suggested that there is a positive relation between refficacy beliefs and performance of the referee and there is a negative relation between refficacy and performance anxiety and stress. They explained key confidence components that are part of successful officiating: game knowledge, decision-making skills, and psychological skills, strategic skills, communication/control of game, and physical fitness, as last but not least part of referee's performance.

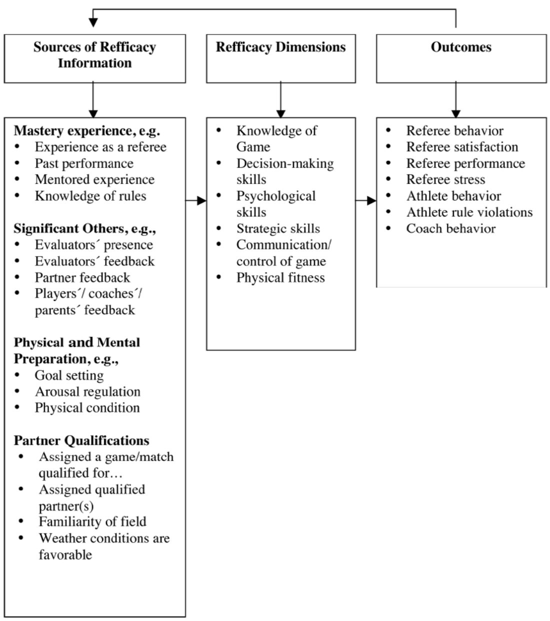

Figure 1. Conceptual model of refficacy (Guillén & Feltz, 2011)

The key requirement for the referee is to get to the right place to be able to make a correct decision in every game situation. Staying up with the play is also mentioned by Guillén and Feltz (2011) as a relevant example of a necessity to be in good physical condition. Conditioning ensures development in two fields. Jansa, Dovalil, Rychtecký and Krauskopf (2007) explain that the first is to acquire of a wide range of motion base and the other is a subsequent development of special motor skills. In harmony with technical and tactical skills, they are a prerequisite for performance at the aspired level. The referee's performance in a match consists of several factors. These include technique and tactics of officiating, mental state, and physical fitness. Technique and tactics are improving with an increasing number of matches. The mental aspect of the performance depends on the personality of the referee. Physical preparedness can be seen as a reflexion of each referee's individual responsible approach, with a possible relation also to the level of competition. On professional level, referees train in cooperation with a fitness coach. However, in lower competitions, the physical preparation of referees is an individualized process based mainly on material and knowledge recommended by regional organizations. Hátlová, Hošek & Slepička (2009) includes the character, temperament and the current mental state among the factors influencing motor performance.

Football referees in the Czech Republic have to pass fitness tests twice a year. The paper deals with the physical preparedness of football referees. It plays a very important role in their performance. It was assumed that referees who officiate in a higher competition should be physically better prepared compared to the referees officiating lower competitions of Czech football league. Generally, a long-term conditioning is based on referees' individual responsible approach. As a help they can use materials provided in seminars by the individual control bodies, or in courses of special training programme for the officials. Recent research confirmed the need of the referees to be physically well prepared in several studies concerned with both physiological and physical parameters measured during sport games. D'Ottavio and Castagna (2001) measured that the main referee has to manage running on average 11.4km, which is similar to the distance run by football players. Krustrup and Bangsbo (2001) analyzed that the referee has to make up to 1300 changed of activities and counted on average there is one change in approximately in every 4 seconds. Castagna, Abt and D´Ottavio (2007) shown that during a competitive match, an elite soccer referee can run 9-13km loaded in the zones of 85-90% and 70-80% of maximal heart rate. 4-18% out of the total run distance is loaded at high intensity. Purpose of the study is to compare physical preparedness of football referees of different competition levels. General physical preparedness plays an important role in motor performance. Coping with the physical loading in games can be seen as a precondition to judge the game correctly.

Methods

Participants

The sample comprised 42 football referees licenced by the Czech Football Association. They were divided in two groups according to the competition level they officiated. The first group (n = 17) comprised referees of the 3rd league and professional competitions of Czech Men Football League, the other group (n = 25) comprised referees of regional competitions of 1.B and 1.A class. The first group is later referred to as "group A", the other as "group B".

Measures and analysis

The indicators of physical preparedness were maximal aerobic capacity (VO_{2max}) and shuttle run test. The participants had to run repeatedly 20 metres distance in the pace given by acoustic signals. The pace is getting faster throughout the test. The score was the number of phases run in the given pace to exhaustion, related to the number of minutes, rounded down to 30s. The maximal aerobic capacity was measured and processed by means of sporttester Polar RS800CX and ProTrainer software. VO_{2max} is counted in milliliters per kilogram of body weight per minute and expresses the maximum amount of oxygen an athlete can use.

The sample was grouped (A/B) as to the performance class of the referees, licenced by the Czech Football Association, and the distribution across the two independent groups was tested. The data were measured on an equidistant scale. With regard to a small size of the sample and the fact that normality of distribution of the basic sample was disproved (K-S, $p<0,05$), nonparametric test was used. The statistical significance of differences between the groups was tested by Mann-Whitney U-test ($p<0,05$). The analysis was done by IBM SPSS Statistics 24. The evaluation was based on mutual comparison of all the data from group A to all the data from group B and testing in favour of which group the results gave evidence. The grouping criterion was the level of football competition the referees were licenced to within the Czech men football league.

Results

The null hypothesis was rejected and a statistically significant difference across the groups was evaluated in both indicators, maximal aerobic capacity (VO_{2max}) and shuttle run test. This verified the assumption that in the given sample, the referees who officiate higher football competitions had better results in terms of physical preparedness.

Concerning the shuttle run test, the score equalled minutes round down to 30s. In group A the referee highest score was 13min, lowest 11min (12.17+/-0.73min), compared to group B, where the highest score was 14.5min, lowest 9min (11+/-1.16min). Comparison of the actual performance in the shuttle run showed the difference of means slightly bigger than 1min and can be interpreted in terms of better performance in the group of 3rd league referees. Maximal aerobic capacity VO_{2max} was recorded in milliliters per kilogram of body weight per minute. The best score in group A was 57.2, the lowest 50.3 (54.18+/-2.55 $ml.kg^{-1}.min^{-1}$). In group B the best score was 62, the lowest 43.3 (50.63+/-3.94 $ml.kg^{-1}.min^{-1}$) Comparison of the actual performance in maximal aerobic capacity showed the difference of means about 3.5 $ml.kg^{-1}.min^{-1}$. The difference is statistically significant and can be interpreted in terms of better performance in the group of 3rd league referees.

Discussion

The assumption of a difference in physical preparedness of football referees in different competitions was based on a fact that training and physical fitness development is not fully unified and controlled. The referees of professional competitions have fitness coaches who prepare recommended training plans. They also have sporttesters at their disposal, so they have a personal feedback when training. On the other hand, the referees of regional competitions do not have fitness coaches and are expected to work more on their own, with a possible support of regional organization. A significant difference was verified in this study, as presented in the findings above. Partial results of this study in Czech referees can be compared to the findings of Casajus a Castagna (2006) in Spanish referees. Maximal aerobic capacity in professional competition in both countries is comparable, with VO_{2max} of 54.18+/-2.55 $ml.kg^{-1}.min^{-1}$ in Czech professional referees and VO_{2max} of 54.9+/-3.9 $ml.kg^{-1}.min^{-1}$ in Spanish professional referees. VO_{2max} score is an indicator of cardiovascular fitness and aerobic endurance. The more oxygen is used during high-level exercise, the more ATP can be produced. In relation to a fitness status, Castagna, Abt and D´Ottavio (2007) found out that football referees' measures of VO_{2max} values were slightly lower than the players they officiate, with mean values in the range of 44-50 $ml.kg^{-1}.min^{-1}$. A high VO_{2max} may indicate a potential for excellent aerobic endurance, but many other factors can determine the individual performance. This is often a case with elite endurance athletes. Quinn (2007) claims that most elite athletes should have VO_{2max} values over 60 $ml.kg^{-1}.min^{-1}$, but the number alone is not a guarantee of elite performance.

Physical demands are laid on sport games referees in general. Castagna, Abt and D'Ottavio (2007) claim that a football referee has to challenge up to 13km distance run during a match, which seems to be more than in other sport games. For example in rugby, the distance can be approximately 8.5km (Martin, Smith, Tolfrey & Jones, 2001). To compare, a distance run by a referee in a handball game is approximately 5km (Da Silva, Castagna, Carminatti, Foza, Guglielmo & De Oliveira, 2010). Referees are expected to perform impeccably, however, there is a wide range of stressors they have to face. Guillén and Feltz (2011) defined the term „refficacy“, as explained in the introduction. Based on a psychological point of view (Bartůňková, 2010), stress can be seen as a state of conscious or unconscious threatening of integrity, when one reacts by anxiety, tension and other defensive mechanisms. The authors believe, that good physical preparedness gives the referee confidence and can help decrease the level of stress when officiating. Example of an attempts to decrease the level of stress when officiating can be found in increased number of referees. In football it is a case of video-referee. Similarly, the number of referees in the top Czech basketball league changed from two to three in 2005, in order to ensure higher quality of the game. Hruša (2014) concerned with the change in comparison of 60 games officiated by 2 and by 3 referees. The change was reflected and supported in lower frequency of negative expressions of player's behaviour.

The findings of this study about better physical preparedness of football referees in the league competition compared to the selected regional competition can support a need of implementing a targeted and unified system of physical preparation training plans being controlled by fitness coaches, in all levels of football competitions. Similarly, Mitáš, Amler, Bedřich, et al. (2013) also recommend to all the football referees to keep a training diary. As mentioned in the above discussion, training plans and sporttesters are used by referees in professional competitions. However, they do not have to send their data for control or feedback. The only individual feedback for professional football referees is the requirement to pass a compulsory FIFA physical test twice a year. It is taken on an athletic track and it consists of sections of 75m of sprint and 25m of walk (with time limits of 15 and 18s). On regional level, the tests and limits are not unified.

In terms of the sample size and range of levels of competitions the study is considered to be a pilot for further analysis. It would be recommended to do exact laboratory testing. In our research it was not possible to ensure laboratory tests and the terrain shuttle run tests at the sample time. Thus the VO_{2max} is interpreted as an approximate value. The league competition was represented by 3rd league football referees. In order to enlarge and verify the findings a comparison with the top Czech football league should be done.

Conclusion

The research results support the assumption that the football referees of higher competition levels have better level of general physical preparedness, which is one of the key components of motor performance. It is necessary to emphasize that respondents represented only 2 selected groups of referees of 3rd Czech football league and 1.A and 1.B class and the conclusions cannot be generalized in terms of all football referees. The study is considered to be a pilot for further analysis and the project is recommended to be enlarged. To get a complex idea of factors influencing motor performance, further analysis is recommended in terms of psychological, technical and tactical factors.

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BUTTERFLY SWIMMING TECHNIQUE VARIATIONS DURING AN EXHAUSTIVE SWIM EXERCISE

Kalichová Miriam, Polach Marek, Lukášek Miloš, Hlavoňová Dita
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: Fatigue significantly influences not only physiological parameters during swimming, but also the technique of swimming stroke. Fatigue, therefore, affects also swimmer´s performance. This study aims to find out to what extent fatigue influences the technical execution of the butterfly stroke with and without breathing.

Method: This work is structured as a case study. The participant was one of the best Czech and European swimmers, a 50 m butterfly Czech record holder. The swimmer performed a standardized lactate test – 8 x 50 meters butterfly swim. In selected moments, his heart frequency was measured using a sport tester Polar and a blood sample was taken for lactate level test using Lactate scout+ device. A speedometer "Swim-Speedo-Meter" fixed on the belt and a video record was used for the stroke technique analysis. Temporal, spatial and speed characteristics were evaluated from the acquired curve of the swimmer´s speed.

Results: Maximum heart frequency (172 bpm) as well as blood lactate level (14.2 $mmol \cdot l^{-1}$) was reached after fifth 50m track. There was a huge increase in stroke frequency with increasing fatigue. This fact resulted in the decrease in stroke duration from initial 1.37 s to 1.09 s in stroke with breathing and from 1.29 s to 1.06 s in a stroke without breathing. Significant changes during the transition phase from "insweep" to "upsweep" were observed, with a huge decrease in speed. Furthermore, accumulated fatigue caused that the speed developed during "insweep" phase was smaller in the second part of lactate test compared to the previous parts. These major differences in technique negatively influence stroke effectiveness.

Conclusion: The core importance lies in between relations of measured variables that show changes of butterfly stroke technique as swimmer fatigue increased. We recommend to focus on strength and dynamic preparation during training, mainly leg movement during the second kick. We also recommend regular speedometer measurements which can help control changes in technique caused by factors such as fatigue, injury, different period of training annual cycle, etc.

Key words: *speedometry, fatigue, lactate test, stroke technique*

Introduction

Currently, various methods are used to determine the appropriate intensity and volume of training load. Nowadays, the blood testing is the most accurate method for determining the effectiveness of the training process and any changes in the aerobic and anaerobic capacities of the energetic system. Due to high physical demands of butterfly swimming technique, athletes swim crawl in the vast majority of aerobic endurance trainings. For butterfly specialist, it is very important to develop aerobic endurance for specific muscle fibers, and therefore they need to be able to swim butterfly in about 20-30% of the training volume. According to Sweetenham and Atkinson (2006), the complex nature of butterfly increases the percentage of errors in the stroke technique, especially in endurance training, its quality is very often reduced.

Technique of the butterfly stroke is much less studied than crawl or breaststroke (Barbosa, Fernandes, Morouço, & Vilas-Boas, 2008). Maglisho (2003) dealt with biomechanics of swimming styles in detail. He identified four different propulsion phases for butterfly stroke: 1. during „hand entry“ and first „downbeat“, 2. starts in „catch“ position and continues during „in sweep“, 3. during „upsweep“ and the second „downbeat“, 4. during „recovery“ when a propulsion wave is created as a result of the completion of the second kick. Maglischo (2003) mentions that the performance of butterfly stroke is very variable in terms of speed characteristics. He describes an execution with one to five velocity peaks, with the velocity curve with two-peaks being considered as the most efficient. Craig, Termin, and Pendergast (2006) made simultaneous recording of velocity using a tachometer and underwater video of butterfly stroke to demonstrate a typical velocity curve in motion. Similarly to Maglischo (2003), the results of a study by Craig, Termin, and Pendergast (2006) showed a variable course of forward velocity and different number of maximums, from two to five evident peaks.

Lukášek (2014) notes that with the development of fatigue during swimming, the optimal pattern of individual swimming techniques is disturbed. The physical exhaustion occurs much faster especially in the butterfly stroke than in any other swimming styles therefore it is very important to put the same emphasis on the technique during both sprint and endurance training and not to overload the swimmer. Authors who dealt with the impact of fatigue on swimming technique analyzed changes in stroking parameters, mostly in front crawl (Alberty, Sidney, Pelayo, & Toussaint, 2009; Bassan, César, Denadai, & Greco, 2016; Dekerle et al., 2005; Matthews, Green, Matthews, & Swanwick, 2017). From this point of view only de Jesus, Figueiredo, Gonçalves, Vilas-Boas and Fernandes (2012) dealt with the butterfly stroke. These authors contributed to the knowledge about effects of fatigue on butterfly stroke kinematics in female swimmers using a kinematographic method. This method is advantageous in terms of the number of possible evaluated parameters, however, it is unable to provide swimmers with information in real time. Using inertial sensors or tachometers is more appropriate in this respect (Craig, Termin & Pendergast, 2006).

The aim of the work was to reveal what changes in butterfly stroke technique occur due to fatigue in the selected elite swimmer. Another aim was to find out whether the use of a speedometer is a suitable means of determining the quality of a butterfly swim. It was hypothesized that: i) the stroke length shortening and stroke rate increasing will be demonstrated from the speed curve; ii) the stroke technique will get gradually worse with the speed of swimming increasing.

Methods

Participant

This study is structured as a case study, therefore we measured one elite swimmer. The tested athlete was one of the best Czech and European swimmers, a 50 m butterfly Czech record holder. Butterfly disciplines are his specialization, especially 50 m and 100 m long courses. The swimmer participated in both European and World Championships and Olympic Games in 2004 and 2008. He was tested during preparatory training period for Olympic Games 2016 qualification. Existing personal best (PB) time in the 50 m butterfly set in long course (50 m) was 23.70 s, in short course (25 m) 22.88 s. His anthropometric and physiological characteristics are: age – 29 years, weight (m) – 98.8 kg, height (h) – 193 cm, blood pressure (BP) – 120/70 at rest, 200/80 max., heart rate (HR) – 40 beats per minute (bpm) at rest, 196/min max., power-to-weight ratio (PWR) – 6 W/kg, power (P) – 592 W, forced vital capacity (FVC) – 7.71 = 128%, maximum oxygen uptake (VO_2max) – 64 ml/kg/min, anaerobic threshold (AnT) – 164/min = 83.7% HR max., aerobic threshold (AT) – 107 = 54.6%, maximum blood lactate concentration (LA max) - 18-19 mmol/l.

Instruments

For testing we used the following measurements: heart beat frequency, blood sample for testing lactate level, horizontal velocity record and 2D kinematographic record of the movement. The heart beat frequency was measured using a sport tester Polar and blood was taken for the following tests: lactate level using Lactate scout+ device.

For measuring the horizontal velocity we used a tachograph “Swim-Speedo-Meter” (Sporttec, Germany). This device was fixed on the side of the pool, at a height of 60 cm above the water surface. The tested person was connected to the speedometer by a non-stretchable cable which was attached to the belt around swimmer´s hips. The unwired cable cannot be in a horizontal position due to technical reasons but it forms an angle of 4-6° with the water level. Since the stroke was analysed at a distance of 6-8 meters from the device, the error in the result due to the change in angle is minimal. All measurements are burdened with the same error so we did not recalculate the measured values. When swimmer moves forward, the cable unwinds and spins the spool inside the speedometer. The spool is hindered by an electric motor to preclude inertial spool unwinding when the swimmer moves with high acceleration. The spool is connected to a tachometer which responds to variations in speed by changing the voltage. This is transferred to a notebook via an analog-to-digital converter where data are saved in the BMCM software for next data processing. Sampling frequency was set on 200 Hz.

The kinematic motion recording was performed using a GoPro waterproof camera that moved on a roller console along the pool. This material served only for auxiliary purposes.

Procedures

Measurements took place in an indoor 25 m long swimming pool in the morning. The water temperature was 25.6 ° C. Testing was carried out during the preparatory training period, so the measured values would probably be slightly different from those we would get in “top form” with a precise technical performance.

The swimmer passed the standardized efficiency test under pressure 8 x 50 m butterfly. This set is high short and high intensity thus it provides information on anaerobic metabolism. Existing personal best time of the competitor in the 50 m butterfly set in short course (25 m) was 22.88 s. Each lap time is related to the swimmer personal best (PB): 1st 50m = PB + 10 s, 2nd 50m = PB + 10 s, 3rd 50m = PB + 10 s, 4th 50m = PB + 8 s, 5th 50 s = PB + 6 s, 6th 50m = PB + 4 s, 7th 50m = PB + 2 s, 8th 50m = PB + 1 or best effort (table 1). During the test the swimmer should aim to hold constant stroke count even though swimming is progressively faster.

Table 1. Test procedure steps, lap – number of the lap 1 – 8, lap time / s – recommended lap time in relation to PB, start/ min – starting time from the previous start, speedometry – recorded strokes at second length of selected laps, LA interval 1 – first time interval for blood taking, LA interval 2 – second time interval for blood taking

lap	**lap time / s**	**start / min**	**speedometry**	**LA interval 1**	**LA interval 2**
1. 50 m	PB + 10				
2. 50 m	PB + 10	1			
3. 50 m	PB + 10	1	6. + 7. stroke	1 minute	
4. 50 m	PB + 8	3			
5. 50 m	PB + 6	1	6. + 7. stroke	1 minute	
6. 50 m	PB + 4	3			
7. 50 m	PB + 2	5	6. + 7. stroke	1 minute	3 minutes
8. 50 m	PB + 1	20	6. + 7. stroke	3 minutes	5 minutes

Heart rate was recorded during the whole test. This method helped us to determine the degree of fatigue during the test, and also served as a control of blood testing. Blood was collected according to the established rules of the standardized 8 x 50 m swimming test sequentially after the third, fifth, seventh and eighth laps with a predetermined time interval and number of repetitions. The swimmer was measured four times using the speedometer during the test. We analyzed swimming stroke with and without breathing always before taking blood. Exactly it was the 6th and 7thstroke of the second length of selected laps with "hand entry phase" considered the beginning of the cycle. These sections were also recorded on the camera, which facilitated the technique analysis. The procedure for individual measurements is explained in the Table 1.

Data analysis

From blood we evaluated blood lactate level (LA).Key variables were obtained using a speedometer. We transferred the source data in ASC format to the Microsoft Excel programme where we processed them in detail and created charts of the forward speed. The curve was smoothed by the moving average function to eliminate measurement inaccuracies caused by, for example, vibrations of the cable for various reasons.

We evaluated the time of each lap and number of strokes per minute. In four strokes with breathing and four without breathing we focused on parameters - one stroke duration and length, the maximal, minimal and average velocity. 50 m swimming times will be taken as supplementary data because the times of measured laps are not accurate due to the handling of the speedometer. Using a synchronized camera record we were able to determine which swimmers' movements are related to the speed curve increases and decreases.

Results

The degree of fatigue was assessed by the physiological parameters of heart rate and blood lactate concentration (table 2). At the end of the first 50 m lap, the heart rate value reached 151 bpm which exceeds the aerobic threshold. In the second 50 m lap this variable rose to 165 bpm, the swimmer just exceed the anaerobic threshold and reached the lower limit of the anaerobic zone. In next laps the heart rate value even slightly increased up to 172 bpm. After a 5-minute pause between 7th and 8th lap the heart rate decreased significantly. Then, during the 8th lap, the heart rate was 140 bpm, below the anaerobic threshold.

Table 2. Results of measured variables: LA – blood lactate level, HR – heart rate, stroke rate – strokes per minute, t 50m – 50 m swimming time, v max – maximal velocity, v min – minimal velocity, v avg – average velocity, t stroke – one stroke time, stroke length – length of one stroke

measuredphases	LA mmol/l	HR bpm	t 50m s	stroke rate N/min	strokewithoutbreathing					strokewithbreathing				
					v max m/s	v min m/s	v avg m/s	t stroke s	stroke length m	v max m/s	v min m/s	v avg m/s	t stroke s	stroke length m
1. 50 m		151	31,2											
2. 50 m		165	31.3											
3. 50 m		167	32.9	45.2	1.96	0.82	1.42	1.29	1.83	2.01	0.73	1.39	1.37	1.90
1 minute	6.2													
4. 50 m		165	29.3											
5. 50 m		172	31.2	49.0	2.17	0.78	1.48	1.21	1.79	2.18	0.84	1.48	1.24	1.84
1 minute	14.2													
6. 50 m		170	27.9											
7. 50 m		167	28.4	53.6	2.32	0.92	1.59	1.12	1.78	2.20	0.93	1.57	1.12	1.76
1 minute	10.4													
3 minute	11.8													
8. 50 m		140	28.7	55.8	2.18	0.92	1.61	1.06	1.71	2.33	0.92	1.56	1.09	1.70
3 minute	8.1													
5 minute	7.8													

From speedometry we evaluated temporal and speed parameters of butterfly stroke with and without breathing. According to the requirements of the standardized test of 8 x 50 m, the lap time was gradually decreasing, with a corresponding increase in the average swimming velocity to 1.61 m/s in stroke without breathing. From the recorded velocity curve, it can be seen that during the test, i.e. with increasing swimming speed and developing fatigue, the stroke length was gradually reduced from 1.83 m to 1.71 m in stroke without breathing and from 1.90 m to 1.70 m in stroke with breathing. These changes were accompanied by shortening of stroke time from 1.29 s to 1.06 s in stroke without breathing and from 1.37 s to 1.09 s in stroke with breathing. As a result of these changes, we observed an increase in the stroke rate from average value of 45.2 strokes per min to 55.8 strokes per min.

In addition to these changes, comparable to changes in other swimming styles, we also focused on changes in the forward speed curve that is specific to the butterfly style and is incomparable with other styles. As we can observe in the Figure 1a) the swimmer was able to distinguish four propulsion phases in the first two measurements, i.e. at the lower degree of fatigue. The first peak occurred at the time of first downbeat, then we observed a significant drop in speed associated with the catch phase. Subsequently, the speed values increased again until they reached the second maximum in the insweep phase. After a slight decrease in velocity, when moving the arms from the insweep to the upsweep phase, the increase to the third maximum associated with the upsweep and the second downbeat occurred. This is followed by the fourth maximum called propulsion wave.

When analyzing strokes in the 7th and 8th lap we found out that there were significant changes especially in the second part of the stroke, as shown in the Figure 1b.

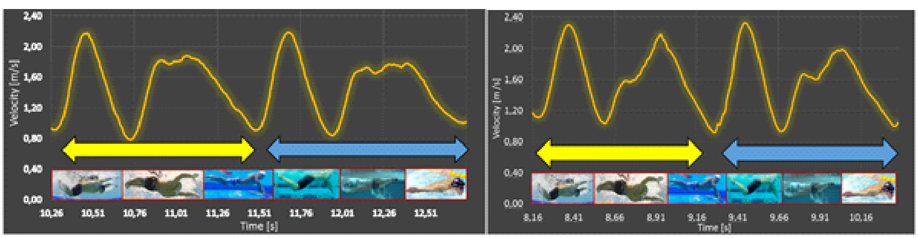

Figure 1. Curve of horizontal velocity for a) the 2nd measurement b) the 4th measurement; first part (yellow arrow) of the curve corresponds to the stroke without breathing, the second part (blue arrow) to the stroke with breathing

Discussion

The goal of this study was to determine changes in butterfly stroke caused by fatigue development. It is possible to distinguish two different conditions under which the effects of fatigue on swim technique can be observed – race conditions and conditions determined by the swimming stress test. We chose an exhaustive swim test for our pilot study. The main results were that the stroke length and time was gradually decreased and the stroke rate was increased. Therefore, the hypothesis that: i) the stroke length shortening and stroke rate increasing will be demonstrated from the speed curve was confirmed. In literature, other authors, who verified changes in the stroke technique during exhaustive swim exercise, usually in crawl, most often evaluated the same parameters as we did, with similar results (Alberty et al., 2009; Dekerle et al., 2005; Figueiredo et al., 2013, Pelarigo et al., 2016). We consider a decline in muscle strength after swimming load as a cause of these changes (Bassan et al., 2016). Dekerle et al. (2005) found out that the speed from which the stroke length in front crawl decreases significantly highly correlates with the maximal lactate steady state swimming speed. Figueiredo et al. (2013) observed significant changes in crawl stroke mechanics at swimming velocities at which the anaerobic threshold was exceeded. Because of the nature of the 8 x 50 m test, the heart rate and lactate concentration did not increase linearly as a function of swimming speed or time. The blood lactate concentration increases with swimming velocity (Figueiredo et al., 2013), but the relation between these variable is not linear (Chollet, Chalies, & Chatard, 2000). With regard to the monitored kinematic parameters, their gradual changes during the four speedometer measurements were almost linear: stroke rate $r^2 = 0.98$, stroke length without breathing $r^2 = 0.91$, stroke length with breathing $r^2 = 1$, stroke time without breathing $r^2 = 0.99$, stroke time with breathing $r^2 = 0.94$. However, changed ratio of these variables when swims at high speed cannot be consider optimal because the efficiency determined by stroke rate – stroke length combinations decreases (Craig & Pendergast, 1979).

During the test, our swimmer switched from the stroke with 4 to 3, and then to 2 peaks where the arms movement in the water associated with the second downbeat created only one maximum. These results correspond with previous findings that the motion variability is more significant in the second part of the stroke (Craig, Termin, & Pendergast, 2006). Thus, it is obvious that the swimmer has come from well-technically to forcefully executed propulsion movements. It could be caused by lower hand horizontal displacement in the water (De Jesus et al., 2012) and reduction of the hand motion speed (Suito et al., 2008). The peak velocity associated with the propulsion wave formation was absent. The swimmer was no longer able to coordinate the completion of the second kick with the transfer of arms over the water in the right timing and dynamically enough to create acceleration. These facts are consistent with our assumption that the stroke technique will get gradually worse with the increasing speed of swimming. This could be explained by changes in swimmer's shoulder strength, thus reducing range of motion in the joint, especially external rotation (Matthews et al., 2017).

We do not notice any significant differences when comparing the velocity curve of the stroke with and without breathing. Noteworthy is the fact that the speed does not rise to such a maximum in the second phase of the stroke with breathing as in the stroke without breathing, which is the reason for the lower average forward speed during a given stroke. However, these differences are insignificant compared to changes caused due to fatigue and increasing speed of swimming.

We believe that changes in technique are due to increased fatigue, but some changes in motion kinematics may also be related to increasing swimming speed during the test. Based on this study, therefore, we cannot clearly demonstrate what caused the temporal and velocity changes in the motion structure. For this reason, it would be appropriate to verify the effect of these factors on changes in the butterfly motion mechanics.

The results of our study are comparable to those of other authors who used the computerized kinematography for the motion analysis. The same findings were obtained by Morouço et al. (2006) who verified the validity of the speedometer measurements in swimming. The advantage of this case study is the fact that we have obtained the relevant data of the elite swimmer using the measuring method that permit to repeatedly gather comparable data. We are therefore convinced that a speedometer is a suitable mean of determining the quality of a butterfly stroke.

There are also limitations associated with the standardized lactate test character in which both swimming speed and fatigue have increased. Next studies could be focusing on the question how the fatigue and the swimming speed influence the butterfly stroke technique separately.

Conclusion

This study focused on the analysis of changes in butterfly technique due to the development of fatigue, which was accompanied by increasing swimming speed. Although it is a case study and the results cannot be generalized, we managed to detect significant changes using a speedometer. In conclusion, due to the above mentioned factors, the stroke length and time shortened and therefore the stroke rate increased in the butterfly stroke. Furthermore, in particular, the change in the number of maximums from four to two distinct peaks of forward speed was significant. As regards the difference between the cycle with and without breathing, greater variability occurred especially in the second half of the stroke, when the speed did not rise to such a maximum with as opposed to without breathing stroke. The intracyclic variation of horizontal velocity under different intensities and levels of exhaustion should be taken into account in training process. Thus, speedometer is a useful and appropriate mean to analyze technique of butterfly stroke.

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KINEMATIC CHARACTERISTICS OF SIDE SOMERSAULT ON THE BEAM

Krnáčová Adriána, Kyselovičová Oľga, Péliová Katarína
Department of Gymnastics, Faculty of Physical Education and Sport, Comenius University in Bratislava

Abstract

The lack of evidence of biomechanics studies in women artistic gymnastics was the reason why we choose this topic. The aim of our research was to analyse and compare the kinematic characteristics of the side somersault on the beam. We concerned on time characteristics of side somersault. The research sample was represented by two female junior (BH=161 cm, BW=48 kg, BMI=18,5 kg.m^{-2}) and senior (BH=168 cm, BW=56 kg, BMI=20 kg.m^{-2}) Slovak national team members in artistic gymnastics. In our ex post facto research we applied a three-dimensional kinematic analyse used by SIMI Motion 3D. We focused on time characteristics in the key phases of the specific difficulty element on the beam. The element was performed by both gymnasts separately. We assumed the rebound phase is the most important as gymnasts affects the final shape of the element. Results: We found out that at the rebound stage of side somersault only the senior gymnast used the ankle joint force properly. Paradoxically, the length of rebound phase was longer performed by junior gymnast (0,15 s) in comparison with the length of senior gymnast (0,13 s). The flying phase was 0,35 s for senior gymnast and 0,32 s for junior gymnast. *Conclusion*: As this was a pilot study supported by KEGA No. 036PU-4/2016 and VEGA No.1/0954/16 projects and the other research trace areas will be done in the future.

Introduction

Sports gymnastics is characterized by constantly increasing difficulty and individual disciplines undergo progressive developments. During each Olympic cycle appear new valid rules that inform about changes in the difficulty of particular exercise shapes, about the inclusion of new exercise shapes, or the mandatory requirements in competitions. An inalienable part is the aesthetics of movement, which is becoming more and more important. The rules of gymnastics describes technique of individual exercise shapes and the value of the exercise shape, but considering individual page of each gymnast is a sport gymnastics characterized by high variability of exercise shapes technique. It is not possible that two gymnasts perform the same exercise shape exactly by the same way. Each gymnast will acquire its own style over time when performing exercises and the role of the trainer is to be flexible to the needs and abilities of the gymnasts. The trainer has to constantly analyze the individual exercise shapes in the training process, to know the key phases, to see faults in the execution. For better analysis, we are using a biomechanical analysis of motion, which also reveals faults in techniques that we cannot see through the free eye. To the trainers helps analyze the motion recorded video during practice exercise shapes. According to Kolar et al. (2017), which dealt with the biomechanical analysis of two exercise shapes "Dimic" and "Bilozerchev" on the male parallel bars, considers feedback using video as an important part on analyzing movement. He found that the exercise shapes he had recorded had done with minimal difference from an adequate technique. He found that the exercise shapes he recorded performed with minimal difference from an adequate technique. Based on the analysis of the exercise shapes, the trainer can successfully eliminate the shortcomings in the technique.

In the research, the dependency between the level of strength development and the practice of training techniques, confirmed research at the Russian gymnastics school. They claim that fitness training focused on the development of strength, speed and endurance is necessary for training, respectively for improving the exercise shapes for the correct demonstration of the techniques they have in their competitive formations (Arkaev and Sučilin, 2004).

The trainer must also be aware of the morphological and anthropo-motoric characteristics of the trainer, because it is also one of the reasons for the correct implementation of the exercise shapes. Potop (2014) in a work on biomechanical analysis of key phases in the realization of jump from beam, points to the kinematic and dynamic characteristics of jumps. His research has shown that anthropometric and biomechanical indicators are necessary for the implementation of biomechanical analysis.

For her research, Ruščinová (2010), also chose the beam, which deals with the analysis of the technique of a turnover exercise shape on beam - fast loop without hand support with a landing on single leg. She determined differences in the technique of presentation, namely the time and space characteristics of the chosen exercise shape at first-rate sports gymnastics using a cinematic recording. She found that the longer step in the first phase had a significant impact on the performance of the "exercise" in terms of flight velocity and height.

In our report we were dealing with a three-dimensional biomechanical analysis of motion, namely we investigated the time characteristics of the loop exercise shape of the side somersault "kabolo". We have chosen this exercise shape because of the high difficulty. The difficulty value is D, which means a 0.4 point bonus. This exercise shape is very common in junior and senior gymnastics competitions. In the area of three-dimensional kinematic analysis, it is pilot work in Slovakia.

The aim of our work was to analyze and compare the time characteristics of the loop exercise shape side somersault on the beam.

We assumed that the length of the reflection phase will positively affect the length of the flight phase, and we also assumed that both gymnasts would use the work of the ankle joint in the reflection phase.

Based on our goal of work, we have set the following tasks.

Perform a kinematic analysis of the side somersault on the beam.

Analyze and evaluate differences in time characteristics of the side somersault on the beam.

Methods

Our research team consisted of two representatives of the Slovak Republic in sports gymnastics. The selection of the gymnastics was deliberate, it was specifically the proband No. 1 - the representative of the SR in the senior category and proband No. 2 - representative of SR in junior category. Both gymnasts regularly practiced 6 times a week, attending domestic as well as international events such as Championship of SR, Europe and World, Olympics games and EYOF.

Table 1. Basic characteristics of probands

Proband	Year of birth	Body height (cm)	Body weight (kg)	BMI (kg.m-2)
Proband No. 1	1997	168	56	20
Proband No. 2	2002	161	48	18,5

For the methodology of the work, we obtained the data by analyzing the kinematic structure of the loop exercise shape side somersault - kabolo - on the beam, specifically by analyzing the time characteristics of the exercise shape. We obtained a lot of factual material and we used the following methods:

- observation method - direct observation and using video recording,
- cinematographic method - video recording as factual material
- method of measurement - body height and weight of gymnastics
- three-dimensional kinematic analysis using programme SIMI Motion 3D

We were unable to use the laboratory conditions to record movement and obtain usable records, but the research was realized at a specialized gymnastics gym TJ Sokol Brno. We used a competition beam on which the gymnasts exercised. To carry out and record a given movement, it was necessary to bring the equipment as a computer, a cam synchronizer, cameras, markers, and so on. To capture video for three-dimensional kinematic analysis, we used three industrial high-speed cameras Basler with a frame rate of 10 Hz. The cameras were scA640-12gc with a Fujinon 1: 1.4 / 3.8-13mm lens and LED illumination mounted on the stand Manfrotto. The recorded videos were moved using optical cables and stored on a hard disc of high-performance computer with Intel® Xeon (R) CPU E5-1620 v2 CPU with and 3.7GHz speed and 8GB of Random Access Memory (RAM). Video recordings saved to the hard disc in .avi format at a resolution of 656x492 pixels at a rate of 100 frames per second. The entire recording and storage process used programme SIMI Motion 3D version 8.5 from the German company SIMI Reality Motion Systems GmbH based in Unterschleissheime. To run this analytics software, was necessary to plug the USB license key that delivered with the program. Before performing the analysis, it was necessary to identify points for tracking and digitization in the SIMI Motion 3D program on bodies of probands. In our case it was 14 points, which can be seen in figure No. 1. We then placed passive light-reflecting markers on them, which later served us for better visibility when marking. The markers were glued reflective tape. Calibration was done before the recording of exercise shape was done. Because we used 3 cameras for our research, we did a calibration record on all three high-speed cameras. Calibration itself is extremely important for subsequent calculation. We used a Wand calibration rod that is 80 cm long and has markers at specific points. We moved the bar throw the places where the exercise shape was realized and the space was calibrated using the software. We also used the L-Frame bar, in which the markers were placed at the centre and at the ends, through which we calibrated the X and Y plane. L-frame calibration was much quicker and more convenient than manual calibration point calibration using the Wand calibration bar, where we had to write the exact dimensions on each camera separately. We used the graphical method, time characteristics (SIMI Motion 3D) and Time View (Motion View) when processing and evaluating data.

Results

In our work we monitored the time characteristics in the execution of the loop exercise shape of the side somersault - kabolo - on the beam. We have divided the exercise shape into the following phases:

Preparatory phase – Initial position and single step forward, this phase started from the starting position to the lowest position of the lower limb before the rebound

Phase of rebound – from the lowest position of the lower limbs before the rebound to the last contact of the foot with the pad

The flight phase – from the last contact of the foot with the pad to the first foot contact with the pad, consisted of two parts, Part 1 – from the last contact of the foot with the pad to the head position perpendicular to the tool, Part 2 – head perpendicular to the tool after the first foot contact with the pad

Landing phase – from the first contact of the foot with the pad to the final position of the body, which ended in knee-bend slightly straddle.

From a time view, we observed the duration of the individual phases of the exercise shape of probands. Proband No. 1 carried out kabolo from two steps. Our task was to start taking into account the time aspect of the duration of the exercise shape from the moment, when she was in the position on single gimp leg and rebounding leg is in the front. It was leg extension (straight) lower. We stopped the movement of the exercise shape at the moment when she moved the center of gravity over the surface of the adminicle. Total execution of exercise shape by proband No. 1 took 1.97 s. Proband No. 2 exercised from place and the rebounded leg she had in position leg extension upper, so it was easier to capture the moment when the movement began. Exercise the exercise shape of proband No. 2 took 2.16 seconds, which was 0.19 seconds longer than that of proband No. 1.

In Table No. 2 we can see the duration of the individual key phases of the exercise kabolo shape on the beam.

Table 2. The time characteristics of the side somersault

Key phases	**Proband No. 1**	**Proband No. 2**
Preparatory phase	0,63 s	0,83 s
Phase of rebound	0,13 s	0,15 s
Flight phase	0,35 s	0,32 s
Landing phase	0,86 s	0,86 s

On the basis of the data in the table, we can see how long took the individual key phases of the exercise kabolo on the beam at proband No. 1 and No. 2. The initial position, which was leg extension lower at proband No. 1, and in proband No. 2 with leg extension upper began at 0.0 s. The preparation phase started from the initial position and by step out to forward. This phase started from the starting position to the lowest position of the lower limb before the reflection and lasted 0.63s for the proband No. 1 and 0.83s for proband No. 2.

We believe that the difference of 0.20s in the preparatory phase between the probands was mainly due to the fact that proband No. 1 performed the two-step kabolo and the second step was faster, because she took by the first step faster than the proband No. 2, which performed the exercise shape of the kabolo from the place.

The rebound phase, which began from the lowest position of the leg before the rebound to the last contact of the foot with the pad, lasted 0.13 seconds at proband No. 1 and 0.15 seconds for proband No.2. We assumed that both gymnasts would perform the rebound phase mainly from the ankle joint and will use the work of the foot. While watching the video, we found that proband No. 1 used the work of the ankle joint at rebound, but proband No. 2 did not at all use the work of the ankle joint in rebound, that is, she didn't use foot work, which is very important in sports gymnastics and improves the quality of rebound. Paradoxically, despite this knowledge, the rebound phase of proband No. 2 is for 0.02 s longer than for proband No. 1. If proband No. 2 completed the phase of rebound technically correct and would use more foot work, it would take its rebound phase even longer and positively affect the length and height of the flight phase, which would give it more time for a safe landing. This phase of the exercise shape is very important as it affects the entire exercise shape. At this stage, the swinging lower limbs of both gymnasts were at their peak (leg flexion), almost in the lateral cleft and using the swinging work of the swing lower limb. On the last contact of the foot with the pad, they had both legs stretched.

The flight phase has been defined since the last contact of the foot with the pad after the first foot contact with the pad. This phase consisted of two parts, Part 1 - from the last contact of the foot with the pad to the head position perpendicular to the tool, Part 2 - head perpendicular to the tool after the first foot contact with the pad. The total duration of the flight phase at proband No. 1 was 0.35 sec, the first part was 0.13 sec and the second part was 0.22 sec. In the first part of the flight phase in the head position perpendicular to the beam, proband No. 1 held only the lower limb below the knee, proband No. 2 kept both lower limbs perpendicular to the shoulder in the head position. The centre of body gravity was also perpendicular to the beam. Duration of the flight phase of proband No. 2 was 0.32 seconds. Proband No. 2 took the first part of the flight phase 0.18 seconds and the second part 0.14 seconds. We can see that the flight phase lasted longer for proband No. 1 by 0.03 s, but a big difference can be seen in the first and second part of the flight phase, where proband No. 1 had the first part of the flight phase was shorter and the second part of the flight phase was longer and she creating more time for a safe landing and for proband No. 2 it was exactly the opposite. She took longer for the first part of the flight phase and the shorter second part of the flight phase. Based on many years of experience, we allow ourselves to be persuaded that the presentation of the exercise shape by the senior representative (proband No. 1) was better realized in terms of ensuring a safe landing as in proband No. 2, as its second part of the flight phase lasted longer than the first part.

Table 3. The duration of the individual parts of the flight phase of the side somersault

Flight phase	**Proband No. 1**	**Proband No. 2**
1^{st} part	0,13 s	0,18 s
2^{nd} part	0,22 s	0,14 s

The last phase that followed the flight phase was the landing phase where we followed the first contact of the foot with the pad to the final position of the body, which ended in knee-bend slightly straddle. The first contact with the pad had the outside of the foot. The landing phase lasted for both probands as well, namely 0.86 s. We divided the phase of the landing into three smaller parts, namely: 1st part - the first contact of the foot with the pad up to the foot with the whole foot on the pad by the swing lower limb. Part 2 - from the landing with the entire foot on the beam with the swinging lower limb to the landing on beam by rebound leg - the moment when both the entire feet are in contact with the pad. Part 3 - Straightening the body to the final position after the landing. The first part of the landing phase lasted for both probands 0.07s. The second part for proband No. 1 took 0.14s and for proband No. 2 was 0.17 seconds. The third part of the landing was 0.65 seconds for proband No. 1 and 0.62s for proband No. 2. From the following, we can see that the 3^{rd} part of the landing phase lasted the longest, where it was about transferring the center of gravity evenly between the two legs above the support surface and straightening the body to the final landing phase.

Table 4. Duration of the individual parts of the landing phase of the side somersault

Landing phase	**Proband No. 1**	**Proband No. 2**
1^{st} part	0,07 s	0,07 s
2^{nd} part	0,14 s	0,17 s
3^{rd} part	0,65 s	0,62 s

Conclusion

In conclusion, our assumption that the length of the rebound phase positively affects the duration of the flight phase has not been confirmed, as the proband No. 1 had a shorter rebound phase (0.13s) than proband No. 2 (0.15s), but its flight phase lasted longer (0.35s) than the flight phase of proband No. 2 (0.32s). Also, the second assumption that both two gymnasts will use the work of the ankle joint in the rebound phase has not been confirmed, as the proband No. 2 did not use the work of the ankle joint sufficiently. For proband No. 1 was a rebound from the front of the foot, and the tip was nearly tensed. Proband No. 2 was rebounded from the entire foot and the work in the ankle joint was inadequate. Because the phase of rebound has in gymnastics a great meaning and utilization of work of sole of the foot in ankle joint is important for correct implementation of various recoils at more gym forms in artistics gymnastics, we would recommend her to engage into the training process following exercises for the improvement of work of rebound and utilization of work of sole of the foot at rebound.

Exercise No. 1 – repeated jumps-on onto a moderately (about 20 – 30 cm) elevated mat double-footedly, also one-footedly.

Exercise No. 2 – step forward onto a moderately (about 20 – 30 cm) elevated mat with subsequent jump-on one-footeedly.

Exercise No. 3 – alternately-legged exchanges of lower extremities onto a slightly (about 20 – 30 cm) elevated mat.

Exercise No. 4 – heels raises double-footedly, also one-footedly on wall bars.

Exercise No. 5 – heels raises in forward bend with load of co-gymnast, so called "donkey" standings on tiptoe (tiptoe positions).

Exercise No. 6 – lying backwards under the vaulting horse, resp. vaulting-buck; the lower extremities to stretch forward into the right angle, the co-gymnast will get on the vaulting horse, resp. vaulting-buck and the gymnast lifts repeatedly the horse, resp. vaulting-buck.

Exercise No. 7 – clear jumps through skipping rope double-footedly, also one-footedly, various variations.

Exercise No. 8 – repeated forward somersaults one after another.

Exercise No. 9 – clear jumps through skipping rope double-footedly on a low balance beam.

Exercise No. 10 – repeated jumps double-footedly on the balance beam with emphasis onto the doing-up of soles of the foot.

This fact, which we detected with video footage, is a major fault in rebound and proband No. 2 should improve its rebound work and the use of foot work during rebounding. It would help it to a higher flight phase of the side somersault and thus safer landing on the beam and also improving the overall performance of the exercise shape. This fact will be dealt with in further work and we will analyze in detail the work in the ankle joint also in terms of spatial characteristics, as we consider it a very important part of the work of the rebounding.

Our work should be of benefit to sports gymnasts and trainers in training and refinement of a exercise shape the side somersault. Through the analysis, we wanted to contribute to the improvement of exercise technique and help to detect the technical errors in each of the key phases and micro phases. The problems of 3D kinematic analysis in sports gymnastics were not addressed in Slovakia due to lack of equipment. They dealt with 2D kinematic analysis of loop exercise shapes, as was in the case Ruščinová (2012), who, for kinematic analysis, chose the exercise shape on the beam, fast loop without hand support with a landing on single leg. In her work she mainly dealt with spatial signs in performing this exercise form, so we cannot compare the time characteristics with her work. It only shows the length of the flight phase, which lasts 0.14 s at both gymnastics, which is, compared to the flight phase "kabolo" for proband No. 1 for longer than 0.21 s and when compared to proband No. 2 the "kabolo" flight phase lasted for 0.18 s longer. Based on the data, we can see that the difference in the duration of the flight phase and the execution of the exercise in terms of time duration is faster than performing the "kabolo" exercise. The kinematic analysis of the kabolo exercise was not carried out in the past.

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ANGLE VALUES AS KINEMATIC PARAMETERS FOR DESCRIBIN-GMOVEMENT ON SKI SIMULATOR

Matković R. Branka, Bon Ivan, Dukarić Vedran, Rupčić Tomislav, Cigrovski Vjekoslav
University of Zagreb, Faculty of Kinesiology

Abstract

Alpine skiing as a winter sport is limited by the specific conditions in which it can be performed. Due to mentioned, athletes and recreational skiers are trying to find alternative activities that can replace snow conditions but are biomechanically similar. Moreover, it is desirable that during mentioned activities, like in alpine skiing, muscles are predominantly eccentrically activated. The PRO SKI SIMULATOR is a possible alternative. It is an exercise machine on which an athlete can perform specific motion biomechanically similar to carving turn performed on an actual ski slope along with predominantly eccentrically activated muscles. The purpose of this study is to measure the kinematic parameters and describe biomechanical model using the MVN BIOMECH XSENS inertial suit while participant performs simulation of the carving turn on the simulator. Participant is a male ski instructor. Kinematic variables that were used are joint angles (ankle, knee, hip, shoulder, elbow), measured in degrees (°), and height of centre of mass measured in centimetres (cm). MVN BIOMECH XSENS inertial suit consists of seventeen wireless motion trackers. It ensures real-time human motion analysis. After adjusting the suit and calibration of the system, participant performs sixteen cycles of turn in each side. PRO SKI SIMULATOR has option of adjusting the resistance by using six springs. Adding each spring resistance increases matching the weight interval of an athlete. In this case resistance of three springs was used. Basic descriptive parameters were calculated for all variables. Variables ADLRT and ADRLT are significantly different (p=0,00); also variables HALRT and HARLT differ (p=0,00). Statistically different is angle of flexion in the outer knee joint (KFLRT, KFRLT) p=0,00; shoulder joint in the abduction (SALRT,SARLT- p=0,00) and flexion (SFLRT,SFRLT- p=0,00). Also to be noted is the difference between elbow flexion (EFLRT, EFRLT- p=0,00). We did not find signifficant difference between outer hip angle of flexion (HFLRT, HFRLT- P=0,58). Height of the center of the mass in right turn was not statistically different from height of the center of the mass in left turn (COMR, COML- p=0,68). From the all obtained results it is possible to conclude that participant does not have the same quality of the left and right turn. The future studies should concentrate on using a kinematic suit but on an actual slope and compare that parameters with ones obtained in this study during laboratory conditions.

***Key words**: Ski simulation, kinematic suit, alpine skiing, biomechanics, rhythm, balance*

Introduction

Alpine skiing as a winter sport is limited by specific weather conditions which are prerequisite for its performance (Cigrovski & Matković, 2015). Ski centres need to fulfil specific requirements; mainly related to amount of either natural or artificial snow during winter period. When ski competitors need to train alpine skiing they either go to glaciers or ski centres on south hemisphere. Glaciers are in general providing good skiing conditions all year long, but due to heights (mainly 3000 m, or higher) training can be hard and challenging. Moreover, training at glaciers or in ski resorts on south hemisphere significantly raises the costs of skiing. Those are some of the reasons why alpine skiers during off season seek for alternative ways of training, which would from biomechanical aspect share similarities with skiing. One of the most important issue is to choose training which is compatible in terms of muscle contractions, primarily sharing eccentric contractions (Hoppeler & Vogt, 2009; Ferguson, 2009). Most similar way of alpine ski training is indoor skiing where snow conditions can be controlled. On the other hand, down side of such trainings is in short length of ski terrains which are also not as demanding, so they are mostly used for training of technical ski disciplines. One of the attractive alternatives is a PRO SKI SIMULATOR, a training machine offering a possibility to perform similar specific movements as those during ski turns at ski slopes (Lee et al., 2016; Nourrit-Lucas et al., 2015). Ski simulator offers different possibilities such as use of ski poles which even more specifically relates to skiing (Moon et al., 2015). Moreover, one can also regulate resistance on the ski simulator by adjusting springs. The aim of our report is to measure kinematic parameters and describe biomechanical model of skier while performing turn simulations on PRO SKI SIMULATOR, with help of kinematic suit.

Methods

This was a single subject analysis and participant was a 25 years old male alpine ski instructor. His weight at the time of investigation was 66 kg and height 174cm. He was informed about the study aims in detail, and gave his consent to participate. Participant performed sixteen turns on a ski simulator, eight in each side. Turns were used as entities for describing movement on ski simulator.

Variables: Kinematic parameters measured in this investigation included angles in different joints (ankle, knee, hip, shoulder, elbow) in degrees (°) as well as centre of mass, measured in centimetres (cm) in both turns on a simulator. Variables were as following: Ankle joint angle of dorsiflexion of left leg in right turn (ADLRT), ankle joint angle of dorsiflexion of right leg in right turn (ADRRT), ankle joint angle of dorsiflexion of left leg in left turn (ADLLT), ankle joint angle of dorsiflexion of right leg in left turn (ADRLT), knee angle of flexion of left leg in right turn (KFLRT), knee angle of flexion of right leg in right turn (KFRRT), knee angle of flexion of left leg in left turn (KFLLT), knee angle of flexion of right leg in left turn (KFRLT), hip joint angle of flexion of left leg in right turn (HFLRT), hip joint angle of flexion of right leg in right turn (HFRRT), hip joint angle of flexion of left leg in left turn (HFLLT), hip joint angle of flexion of right leg in left turn (HFRRT), hip joint angle of abduction of left leg in right turn (HALRT), hip joint angle of abduction of right leg in right turn (HARRT), hip joint angle of abduction of left leg in left turn (HALLT), hip joint angle of abduction of right leg in left turn (HARLT), shoulder joint angle of flexion of left arm in right turn (SFLRT), shoulder joint angle of flexion of right arm in right turn (SFRRT), shoulder joint angle of flexion of left arm in left turn (SFLLT), shoulder joint angle of flexion of right arm in left turn (SFRRT), shoulder joint angle of abduction of left arm in right turn (SALRT), shoulder joint angle of abduction of right arm in right turn (SARRT), shoulder joint angle of abduction of left arm in left turn (SALLT), shoulder joint angle of abduction of right arm in left turn (SARLT), elbow joint angle of flexion of left arm in right turn (EFLRT), elbow joint angle of flexion of right arm in right turn (EFRRT), elbow joint angle of flexion of left arm in left turn (EFLLT), elbow joint angle of flexion of right arm in left turn (EFRLT), height of centre of mass in right turn (COMR) and height of centre of mass in left turn (COML).

Research protocol: Kinematic parameters were measured using kinematic suit MVN BIOMECH XSENS. MVN BIOMECH XSENS inertial suit consists of seventeen wireless motion trackers, battery and 240 Hz output rate and it ensures real-time human motion analysis without an effect on movement or rate of motion. Subject performed turn simulations on a PRO SKI SIMULATOR (Figure 1). Simulator offers option of adjusting the resistance by adding springs. Matching number of springs, situated on a simulator basis, is attached on a cart on which subject is standing. Cart is moving laterally on two parallel guides. There are six levels of resistance each matching the weight of an athlete. One spring equals certain weight interval. In this case resistance of 3 springs was used which matches weight interval from 65 to 80 kilos. After dressing the suit and adjusting the sensors, calibration of the system was performed, and subject performed 16 simulations of turn in each side. The ski simulator (Pro ski simulator; Slovenia) was fixed to a flat surface consisting of a platform on wheels moving left and right on two bowed parallel metal rails. Rubber belts fastened the platform to the rails and ensured that it regained resting position in the middle of the apparatus.

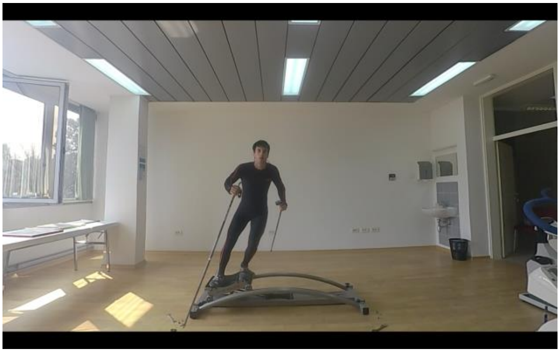

Figure 1. An athlete on a PRO SKI SIMULATOR

Statistical methods

Data was analysed by statistical program Statistica ver. 12. Basic descriptive parameters were calculated for all thirty (fifteen in each turn) previously described variables. In further analysis we measured outer joint angles in relation to the axis of the turn rotation and height of the center of mass. T-test was conducted in order to determine the difference between each outer joint angle in right turn with associated outer joint angle in left turn, and also to differentiate the height of the center of the mass in right turn and in the left turn. Significant difference was considered at $p<0.05$.

Results

In total thirty variables were measured; fifteen in each turn. As noted above only outer joint angles and height of center of mass were described in this paper. In Table 1 are shown basic descriptive parameters for those variables. Table 2 is showing results of t-test. Six variables were associated with $p<0.05$. Variables ADLRT and ADRLT are significantly different ($p=0,00$); also variables HALRT and HARLT differ ($p=0,00$). Statistically different is angle of flexion in the outer knee joint (KFLRT,KFRLT) $p=0,00$; shoulder joint in the abduction (SALRT,SARLT- $p=0,00$) and flexion (SFLRT,SFRLT- $p=0,00$). Also, difference between elbow flexion (EFLRT,EFRLT- $p=0,00$) was statistically significant. There were no signifficant differences between outer hip angle of flexion (HFLRT,HFRLT- $P=0,58$). Height of the center of the mass in right turn was not statistically different from height of the center of the mass in left turn (COMR,COML- $p=0,68$). The same methodology can be used for comparison between simulated turn on PRO SKI SIMULATOR and turn on an actual ski slope.

Table 1. Descriptive statistics for sixteen chosen variables

Variable	M	Min	Max	SD
ADLRT	79,9	77,1	84,2	1,8
ADRLT	84,1	80,9	89,5	2,2
HALRT	169,3	165,5	173,4	2
HARLT	164,5	161,8	168,7	1,7
HFLRT	160,3	157,8	164,5	1,7
HFRLT	160,6	157,6	166,6	3
KFLRT	143,7	140,3	148,8	2,9
KFRLT	148,2	144,6	153,3	2,7
SALRT	46,7	45,2	48,6	1,1
SARLT	58,2	56,1	61,3	1,4
SFLRT	56,5	49,6	65,1	3,5
SFRLT	60,2	54,3	61,8	1,8
EFLRT	52,3	42,6	59,5	4,8
EFRLT	40,7	35,7	48,6	3,1
COMR	94,7	93,5	97	0,8
COML	94,8	94	95,7	0,5

Notes: ADLRT - Ankle joint angle of dorsiflexion of left leg in right turn; *ADRLT- Ankle joint angle of dorsiflexion of right leg in left turn; HALRT - hip joint angle of abduction of left leg in right turn; HARLT - hip joint angle of abduction of right leg in left turn; HFLRT- hip joint angle of flexion of left leg in right turn; HFRLT- hip joint angle of flexion of right leg in left turn; KFLRT- knee angle of flexion of left leg in right turn; KFRLT- knee angle of flexion of right leg in left turn; SALRT- shoulder joint angle of abduction of left arm in right turn; SARLT- shoulder joint angle of abduction of right arm in left turn; SFLRT - shoulder joint angle of flexion of left arm in right turn; SFRRT - shoulder joint angle of flexion of right arm in right turn; EFLRT - elbow joint angle of flexion of left arm in right turn; EFRLT- elbow joint angle of flexion of left arm in right turn; COMR - height of centre of mass in right turn; COML - height of centre of mass in left turn*

Table 2. T-test results

Variable	**M**	**SD**	**t**	**p**
ADLRT	79,90	1,78		
ADRLT	84,10	2,24	6,25	0,00*
HALRT	169,30	2,02		
HARLT	164,50	1,75	-7,61	0,00*
HFLRT	160,30	1,67		
HFRLT	160,60	2,98	0,57	0,58
KFLRT	143,70	2,92		
KFRLT	148,20	2,66	7,47	0,00*
SALRT	46,67	1,11		
SARLT	58,24	1,42	-30,79	0,00*
SFLRT	56,47	3,52		
SFRLT	60,16	1,80	-4,05	0,00*
EFLRT	52,34	4,76		
EFRLT	40,66	3,08	8,21	0,00*
COMR	94,73	0,81		
COML	94,83	0,47	-0,42	0,68

Notes: * $p<0.05$; *ADLRT - Ankle joint angle of dorsiflexion of left leg in right turn*; *ADRLT- Ankle joint angle of dorsiflexion of right leg in left turn; HALRT - hip joint angle of abduction of left leg in right turn; HARLT - hip joint angle of abduction of right leg in left turn; HFLRT- hip joint angle of flexion of left leg in right turn; HFRLT- hip joint angle of flexion of right leg in left turn; KFLRT- knee angle of flexion of left leg in right turn; KFRLT- knee angle of flexion of right leg in left turn; SALRT- shoulder joint angle of abduction of left arm in right turn; SARLT- shoulder joint angle of abduction of right arm in left turn; SFLRT - shoulder joint angle of flexion of left arm in right turn; SFRRT - shoulder joint angle of flexion of right arm in right turn; EFLRT - elbow joint angle of flexion of left arm in right turn; EFRLT- elbow joint angle of flexion of left arm in right turn; COMR - height of centre of mass in right turn; COML - height of centre of mass in left turn*

Discussion

Obtained results indicate that outer joint angle in a relation to the axis of rotation during right turn differs from outer joint angle during left turn. Similar results appeared in six cases (between six joints), regardless of uper or lower segments of the body. Skier is trying to regain optimal dynamic balance and central balance position by using upper body and hands (Loland, 2009). During ski turn, skier tries to separate movements produced in the upper and lower part of a body, where lower part makes several synchronized movements in different planes. Movements connected in right order and in timely manner represent a ski turn. Therefore, lower body parts directly affect the ski turn, while upper body parts assist in realization of a turn by helping the skier to get into the perfect balance position and maintain the balance position through the turn (Hydren et al. 2013). If a skier for some reason makes a mistake and disrupts the ideal trajectory of the turn, or loses the rhythm, central position or dynamic balance, he/she will try to correct it through the upper body movements. When regaining of the ideal position cannot be reached solely by upper body, skier must also include movements in lower body, but during mentioned speed of the turn is lost (Hebert-Losier et al., 2014). Span of the angle values in hip angle during abduction in this research correlated with measures obtained in other investigations, some conducted on an actual ski terrain (Hraski & Hraski, 2009). It would be interesting to see comparison between same variables (HALRT, HARLT) measured on ski slope by the same methodology. From the all obtained results we can cautiously conclude that participant does not have the same quality of the left and right turn. Future studies could concentrate on the investigation of the ideal biomechanical model of the ski turn. Moreover, this could set the basis for distinguishing low quality turns. Future studies should also concentrate on using a kinematic suit on an actual slope and compare measured parameters with ones obtained during laboratory conditions. Only then it would be possible to determine exact similarities in kinematic parameters of simulation turn and turn in snow conditions. Although single subject analyses are valuable tools in biomechanical investigation of the ski turn, future studies should include larger sample of participants to ensure more precise result interpretation.

Conclusions

Mentioned results suggest that movements on PRO SKI SIMULATOR are alike carving ski turn on actual ski terrain and justifies the use of simulators for recreational and professional level skiers in conditions where it is impossible to ski. Recreational level skiers can use it as a preparation for skiing and competitive skiers during specific phases of training.

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ANALYSIS OF ONE-HANDED OVERHEAD THROW BY STUDENTS OF THE 2ND GRADE OF FACULTY OF PHYSICAL EDUCATION AND SPORT OF CHARLES UNIVERSITY

Matošková Petra, Pravečková Petra, Süss Vladimír, Tůma Martin, Carboch Jan
Charles University in Prague, Faculty of Physical Education and Sport

Abstract

Theoretical basis: Overhead throwing is a basic skill for many sports games. This is a natural skill based on human phylogenesis. Mastering this skill is a prerequisite for learning handball and softball that are included in the school curriculum of the primary and secondary schools and therefore they are also the content of the education of future teachers.

Purpose: The aim is to compare the performance of one-handed overhead throw with a softball and handball ball in the group of the Charles University Faculty of Physical Education and Sport students; and determine whether there is a relationship between selected anthropometric data (arm span and forearm length) and the overhead throw velocity.

Methods: The participants were students of the 2nd grade of the Faculty of Physical Education and Sport of Charles University (25 women, 78 men) who were deliberately divided into 4 groups based on whether they were sport games players (volleyball, handball, tennis) or not. The attempts were recorded by the video camera with the frequency of 50 Hz and the velocity was measured with the radar. Software DARTFISH 7 TEAM PRO was used to evaluate the kinematic data using image decomposition at 100 Hz. Significance was evaluated using ANOVA at the 0.05 level of significance and the Bland-Altman diagram. The relationship between anthropometric data and throwing velocity was evaluated using the Pearson correlation coefficient.

Results: The results of the comparison of the performance of the overhead throw showed statistically and practically significant differences in the velocity of the ball with the softball and handball ball in all groups except for the group of women who did not play selected sports games. The relationship between the arms span (forearm length) and the throwing velocity of the handball and softball ball has not been demonstrated. The results of the comparison of throw technique have shown high variability in performance and mistakes during the throw in groups that did not have previous experience with selected sports games.

Conclusion: The results of the study show the unsatisfactory performance of the monitored skills. This may be caused be the insufficient amount of hours of exercises spent on these games in the Faculty of Physical Education and Sport curriculum.

Key words: *overhead throw, softball, baseball, velocity, anthropometric data*

Introduction

Throws are among the basic natural skills based on human phylogenesis. The throws include a specific set of open skills, characterized by the task of giving the object (ball) an acceleration that allows the flight of the object to a certain distance. Kreighbaum and Barthels (1990) list four categories of these skills:

1. bottom patterns (softball pitch, underhand serve in volleyball or badminton etc.)
2. side patterns (discus throw, tennis shots – forehand and backhand etc.)
3. top patterns (baseball pitch, javelin throw etc.)
4. kicks (in football or American football)

Véle (2007) and Süss (2006), on the other hand, feature a division only for throws that are in agreement with the first three categories. In sports games, the basic skill is one-handed overhead throwing. This is a basic skill for an individual's game activity, such as pass, goal-shooting, pitching in baseball, but also service in volleyball and in tennis. A number of authors dealt with velocity, f.e. Rivilla-Garcia & Sampedro-Molinuevo (2010) have been testing professional and amateur handball players in their experiment. Bayios & Boudolos (1998) investigated the differences in the velocity and accuracy of shots in several groups of handball players – groups of the 1st highest division, of the 2nd highest division and of students in physical education. Shooting was performed from the ground, after passing the opponent and from the jump. The highest velocity of shooting along with the highest accuracy was shown in the shooting after passing the opponent in both groups of competitive players, but not the students who were different in all the data. Van den Tillaar (2003) conducted an experiment with several Norwegian handball players. He focused on velocity and later on the location of the shot. The most accurate placement and at the same time the fastest shot was about 85 % of the maximum possible shot velocity of these players. Fleisig (2006) dealt with the velocity of baseball pitch. He compared the velocity of different types of pitches. Further, the velocity and performance of the softball throw were discussed in, for example, Süss et al. (2013).

Mastering the throw is one of the basic skills and is therefore a prerequisite for learning handball and softball that are included in the school curriculum of primary and secondary schools and therefore are also the content of the education of future teachers. Performances of one-handed overhead throw in softball vary depending on the length of the throw, but in most cases it is a throw with both legs on the ground. A 15 to 25 meter midfield pass is characterized by a flat ball flight trajectory (parallel to the ground) but a long pass is characterized by an arc trajectory (Süss, 2006). In handball, one-handed overhead throw is executed either by jump or by shooting from the ground (Tůma & Tkadlec, 2010). To compare the throwing velocity of the handball and softball balls, we chose a throw from the ground, in a straight ahead direction (not an arc) after the release.

Purpose

The aim is to compare the performance of one-handed overhead throw with a softball and handball ball by the group of Charles University Faculty of Physical Education and Sport students; and determine whether there is a dependence between selected anthropometric data (arm span, forearm length) and the overhead throw velocity.

Hypothesis 1: We suppose statistically significant differences in velocity of handball and softball throw in all monitored groups at significance level $p = 0.05$.

Hypothesis 2: We suppose a significant relationship between selected anthropometric data and maximum handball and softball throw velocity.

Methods

The participants were students of the 2nd grade of the Faculty of Physical Education and Sport of Charles University. There were 25 women (average age 21.8 years, height 169.06 cm and weight 63.4 kg) and 78 men (22.1 years, 181.8 cm, 78.1 kg). The participants were deliberately divided into 4 groups based on whether they were games players (volleyball, handball, tennis, softball) or not (M1, M2 – group of men, W1, W2 – group of women). The first group (M1) consisted of 67 students who did not have experience with the performance of sports games, the second group (M2) consisted of 11 students who had experience with softball, handball, volleyball or tennis. Group W1 was formed by women (n = 16) who did not have experience with performance of sports games and the fourth group of women (n = 9) were women with experience from these sports games. The players participated voluntarily and the research was authorized by the ethics committee of the Faculty of Physical Education and Sport.

This was a descriptive study in which we changed the conditions for a one-handed overhead throw at maximum velocity. We monitored the maximum velocity of the handball and softball balls. The players performed three consecutive handball throws and then three softball throws. The ranking of throws was determined randomly using a random number table. The break between the throws was 1 minute. The players stood 5 meters from the net and had the task of throwing the ball at the maximum velocity to the net at a height corresponding to the height of the throwing player (without the preceding steps). Measurements were made at the beginning of the lesson after the standard warm-up that was led by the teacher. Anthropometric data (arm span and forearm length) was taken on a photograph with labeled points on the body of the student.

The throw velocity was measured using the STALKER PRO II radar (positioned behind the participant). The attempts were recorded by the SONY HDR-CX450OB camera with 50 Hz shots and placed 15 meters from the player perpendicular to the direction of the throw. DARTFISH 7 TEAM PRO software was used to evaluate the 2D kinematic data using image decomposition at 100 Hz. Reliability of anthropometric data measurements was evaluated by three independent evaluators. The evaluators reached an agreement of 99.5 %. Significance was evaluated using ANOVA at the 0.05 level of significance and the Bland-Altman diagram. The relationship between anthropometric data and throwing velocity was evaluated using the Pearson correlation coefficient.

Results

The results presented in Table 1 show the summary of average throw velocity in the monitored groups. The groups M1, M2 and W2 achieved statistically significant and factual differences in the throwing velocity of both balls and confirmed the hypothesis 1. In group W1, the students achieved insignificant differences (statistically and factually) between the throws of both balls and thus, we rejected hypothesis no. 1. Table 2 shows the men´s and women´s results of the measurement of arm span (length from top of the right middle finger to the left), the length of wrists (length from top of the middle finger to the *processus styloideus radii*) and forearms length (size from wrist to the elbow). There were statistically significant differences at the significance level $p = 0.001$ for all three measurements (arm span $F = 96.33$, forearm length $F = 15.32$ and size to wrist $F = 66.55$).

Table 1. Results of throw velocity measurements

	Handball		Softball		ANOVA			B-A
	Mean (Km/h)	SD	Mean (Km/h)	SD	F	0,001	0,05	
M1	69.66	6.72	86.51	7.76	183.30	yes	yes	yes
M2	75.51	10.18	92.06	11.97	11.245	no	yes	yes
Total M	70.49	7.51	87.30	8.60	169.34	yes	yes	yes
W1	52.81	5.71	59.83	7.66	8.63	no	no	no
W2	57.58	6.09	71.09	6.30	21.40	yes	yes	yes
Total W	54.53	6.18	63.88	8.96	18.46	yes	yes	yes

Legend: M1, M2 – group of men, W1, W2 – group of women

Table 2. Results of anthropometric data measurements

Anthropometric data						
	Wrist length		Forearm length		Span of Arms	
	Mean (m)	SD	Mean (m)	SD	Mean (m)	SD
M	0.197	0.011	0.248	0.018	1.817	0.071
W	0.178	0.008	0.231	0.018	1.664	0.055

Legend: M – group of men, W– group of women

There weren´t statistically significant differences in p = 0.01 among groups M1 and M2 resp. W1 and W2.

Table 3 shows the results of the relative values (relative to the student's height) and the value of difference in the height of the right elbow and the right shoulder at the moment of the arm wind up.

Table 3. Results of kinematic data

	Relative height - wind up						Release	
	Ball		Forward step		Position of elbow		Ball	
	Mean (m)	SD	Mean (m)	SD	Mean (m)	SD	Mean (m)	SD
M Hand.	0.930	0.077	0.533	0.088	0.009	0.072	1.020	0.069
M Soft.	0.903	0.091	0.557	0.097	0.044	0.067	0.962	0.073
W Hand.	0.944	0.097	0.454	0.065	0.001	0.084	1.083	0.111
W Soft.	0.955	0.084	0.537	0.390	0.043	0.072	1.027	0.111

Legend: M – group of men, W – group of women, Hand. – handball throw, Soft. – softball throw

The results presented in Table 3 show the insufficient mastery of the throwing technique in that the intra-individual differences in the measured data had a high coefficient of variation (1 %, 120 %). The relative height of the arm cocking (position of ball) in all groups is 90 – 95 % of the body height, which corresponds to the requirements of one-handed overhead throw. Critical value is the relative position of the elbow in the arm cocking, where the students reached the average position roughly at the right arm level, the requirement is that the elbow is above the shoulder level. Here the students reached the highest values of the coefficient of variation, which indicates an unstable performance of throw. The length of the forward step was below the required level (the forward step was too short). Only the W2 and M2 groups achieved more stable values in the forward step and in other kinematic data (the coefficient of variation in these groups was in the interval (1 %, 12 %). In these kinematic data, using Bland-Altman's diagnose the significant difference was not found in performance of throwing both handball and softball ball.

Results of correlation analysis

Correlation analysis using the Pearson correlation coefficient is shown in Table 4. No significant differences are shown between selected anthropometric data and throw velocity.

Table 4. Results of the correlation analysis between throw velocity and selected anthropometric data

	M1 h	**M1 s**	**M2 h**	**M2 s**	**M h**	**M s**
Size of Wrist	0.121	0.020	0.047	0.209	0.064	0.068
Forearm length	0.320	0.120	0.232	0**.439**	0.248	0.054
Arms Span	0.377	0.189	0.107	0.056	0.316	0.142
Body height	0.227	0.102	0.132	0.100	0.221	0.086
	W1 h	**W1 s**	**W2 h**	**W2 s**	**W h**	**W s**
Size of Wrist	0.349	**0.489**	0.107	**0.445**	0.235	0.348
Forearm length	0.127	0.255	0.076	0.036	0.176	0.331
Arms Span	0.210	0.370	0.020	0.312	0.157	0.313
Body height	0.37	**0.453**	0.007	0.040	0.336	**0.425**

Legend: M1, M2 – group of men, M – all men, W1, W2 – group of women, W – all women, h – handball throw, s – softball throw

Discussion

We assumed statistically significant differences in the throwing velocity of the handball and softball ball. The results of the ANOVA and Bland-Altman chart showed statistically significant differences of the throw velocity in all the groups at the significance level of $p = 0.01$ (Table 1), with the exception of the female group consisting of students who did not have a sporting experience with sports games before the start of their studies at Faculty of Physical Education and Sport. Compared with baseball research, for example, Werner LS et al. (2010) (pitching velocity of 129.6 km / h – junior pitchers), in cricket, 120km/h – juniors and 125km/h – expert group (Phillips et al., 2010), students achieved significantly lower values at maximum velocity. But compared to the results study of Bayios & Boudolos (1998), where authors compared the maximum throwing velocity in the handball at students group (v = 60.6 km) and the results of Wagner et al. (2011) (v = 80.28 km/h), the students (M1 and M2) achieved comparable results. For women in softball, the average velocity of the throw is 84.6 km/h, in the range (71.13; 101) km/h, which corresponds to the results of the men's groups.

In comparison to the throw velocity with selected anthropometric data (body height, span of arms, forearm and wrist length) we did not find a significant relationship – hypothesis 2 was not confirmed. In our opinion, the prerequisite for this relationship is the correct throw technique, which was not good in our monitored groups. This is evidenced in particular by the wrong elbow position in the wind up (at the level of the right shoulder but at 60 % below the shoulder) and a very short forward step. There is not much data of the similar measurements in the literature, but for example, Vaverka (2010) reports the relationship between velocity of service and body height of tennis players from the Grand Slam measurements (2008–2009). Wrong throwing techniques may be the cause of many health problems, as shown by the results of studies, e.g. Fleisig et al. (1996, 2009) and others.

Conclusion

The results of the study show the unsatisfactory performance of the monitored throwing and document insufficient quality of physical education. The cause may be the insufficient amount of hours of exercises spent on these games in the Faculty of Physical Education and Sport curriculum. Another reason can be low activity of children in natural movement skills such as ball throwing.

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KINEMATIC ANALYSIS OF MOZNIK ELEMENT ON HIGH BAR

Možnik Marijo[1], Čuk Ivan[2], Šibanc Karmen[2], Supej Matej[2], Ogrin Jan[2]
[1] Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia
[2] Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia

Abstract

In men artistic gymnastics high bar is often described as the most exciting discipline for spectators. Today contemporary high bar routine can include up to five flight elements. As the elements have to be different, also search for new elements is important. The flight elements Tkatchev (executed from front swing, backward vault with split legs to hang) have been developed in the last forty years in different ways. The last version of Tkatchev in Code of Points is since 2007 under Marijo Možnik's name as at World Championship in 2007 he performed stretched Tkatchev with 180^{o} degrees turn into mixed grip. With Možnik's career end and for the purposes of original inventor biomechanics characteristics of Moznik element, we did a kinematic analysis of Moznik element performed by element author. We measured the movement with Qualisys measuring system. Over 70 reflecting markers were attached to specific anthropometrical locations on the athlete's body. Their location was then calculated using 12 synchronized QTM cameras set at maximum of 178Hz and Qualisys software. Marker location was exported to Visual 3D software where with additional athlete's weight and height skeletal model was build. From these model trajectories, velocities, angles, angular velocities, angular momentum and moment of inertia were computed. According to results difficulty of the element is properly set as E value in Code of Points. The first 3D kinematic analyze of Moznik element in the world gave data for evaluation of technique, its methods and to set gymnasts physical preparation.

Key words: *kinematic, Qualisys, Tkatchev, FIG*

Introduction

A contemporary horizontal bar exercise must be a dynamic presentation that consist entirely of the fluid connections of swinging, turning, and flight elements alternating between elements performed near to and far from the bar in a variety of hand grips so as to demonstrate the full potential of the apparatus (International Gymnastics Federation (FIG), 2017a). The standard height of the bar, measured from the floor is 2.8 meters (FIG, 2017b). According to the Code of Points (FIG, 2017a) gymnasts routine should consist of elements from the four different element groups, and each element is evaluated using an ordinal scale, from “A” (the least difficult) to “H” (the most difficult). The second Element group is called “Flight elements”– elements where gymnasts release the bar, make a specific movement in the air and regrasp the bar. In the FIG Code of Points every element has a detail description but some elements are also named after the gymnasts who first registered and successfully performed it at the official FIG competition. An element where gymnast performs from front swing vault backward straddled over bar to regrasp in back swing is named by Russian gymnast Alexander Tkatchev, who did this element at the European Championship 1977. Originally element was designed by scientist Gaverdovskij in 1962 and first performed by Soviet gymnast M. Pitamcev in 1968 (in tucked position) (Gaverdovskij, 1987, p.429). Since the first presentation of Tkatchev element it was upgraded by Yogo in 1979 (Nakasone, 2015) performing Tkatchev from stoop circle (but named by Piatti 1984 (Karacsony Čuk, 2105)), by Ljukin and Nakasone in 1988, they performed Tkatchev stretched, and at same year Ljukin also did Tkatchev stretched with 1/1 turn. In 1992 Lynch performed Tkatchev with ½ turn, in 2007 Možnik performed Tkatchev stretched with ½ turn into mixed el-grip, in 2009 Kierzkovski did Piatti stretched to mixed el-grip and in 2010 Kulesza performed Tkatchev stretched with ½ turn to double el-grip (Nakasone, 2015). In 2009 an article about possible performance of Tkatchev salto tucked was published by Čuk, Atiković & Tabaković, but up to today nobody performed it. Čuk and Colja (1996) prepared a model of developing new element in gymnastics, which consisted of seven phases: an idea of a new gymnastics element; a definition of the hypothetical biomechanics model of a new element; a consistency of the new element with the present Code of Points; a design of methodic, training until successful execution, collecting and analyzing biomechanical data; a definition of optimal biomechanics model of the new element and saving it into data base. Same authors also stated that the first phase is usually random by nature, when coach and gymnast according to their experience and logical thinking want to promote the gymnast with a new element. In year 2006 Tigran Gorički, coach of Croatian national team gymnast Marijo Možnik, came up with the idea of the new element on horizontal bar. To accomplish the new element it took him one year of training and he successfully performed this new element at the 2007 World Championships in Stuttgart and since than it has an “E” value for difficulty. Element was included in the 2009 FIG Code of Points under name – “Moznik” (Figure 1).

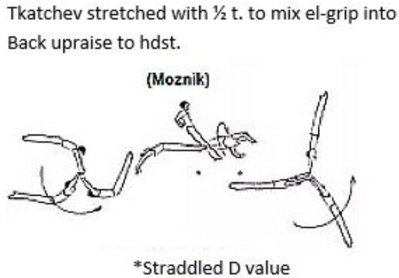


Figure 1. Moznik element as it is described in Code of Points (FIG, 2017a)

Since then Mario Možnik's results at the top level competitions rose: 2015 European Champion; 2014 World Championships bronze medalist; 2012 European championships silver medalist; 2010, 2013 and 2014 World Cup Overall Winner. Precondition for safe and successful learning of "Moznik" element is highly reliable performance of Tkatchev stretched. In the terms of safety for gymnast it is very important to be in the optimal distance from the bar during regrasp, otherwise there is a risk of hitting the bar with the head, or falling on mats. The second major risk is the potential loss of hand contact with the bar due to unfinished turn (fall on mats is a consequence; however landing with turned body is highly risky for spine injuries). Proper initiation and ending time of the turn before regrasp is very important also in the terms of the successful performance of the element (without deduction from the judges). In previous researches many authors did analysis of different Tkatchev element variations, but up to now only Možnik and Hraski (2014) did 2D kinematic efficiency analysis of the Moznik element performance. With new technology (as this element has movement in all three axis) we stated aim to perform a reliable and valid kinematic analysis of Moznik element in order to get data to evaluate technique, and to get data for gymnasts physical preparation.

Methods

Subject of measurement was Marijo Možnik, born 18th January 1987, 183 cm height, and 79 kg weight. We measured the movement with Qualisys measuring system (Qualisys AB, Göteborg, Sweden). Over 70 reflecting markers (Figure 2) were attached to specific anthropometrical locations on the athlete's body according to C-motion protocol (van Sint Jan, 2007). After initial calibration, markers' locations were calculated using 12 synchronized QTM cameras set at maximum of 178Hz and Qualisys software. Marker locations were exported to Visual 3D software (Visual3D v6 Professional, C-Motion, Germantown, USA) where with additional athlete's weight and height skeletal model was build. The first and last frames for the analysis were hang (arms vertical) before release and after the regrasp on the high bar. From those model trajectories, velocities, angles, angular velocities, angular momentum, moment of inertia were calculated. Parameters such as center of mass, moment of inertia and speed of chosen segment and point were computed. The moment of release was defined as moments when the position of the marker placed on the first knuckle of the index finger moved for more than 5 cm relatively to the position of the bar which was defined in the V3D system. When this distance was smaller than 5 cm, this counted as a regrasp. While this was case study, descriptive data was used only.

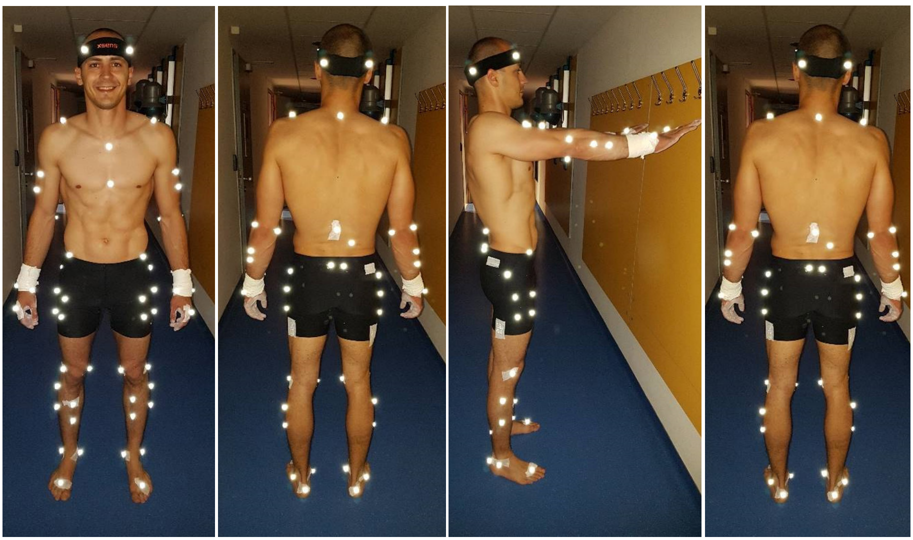


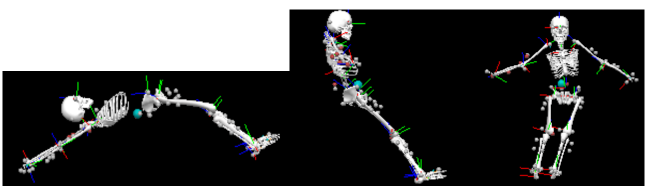
Figure 2. Reflective body markers positions

All measurements were held at Faculty of Sport, University of Ljubljana, Slovenia on 19. 6. 2017 in evening hours, with proper temperature 25^{o} Celsius and humidity of 40% in gym hall. Evening time was selected to avoid sun light reflections on markers. QTM cameras were located around gym hall to cover each marker with at least 3 cameras simultaneously (Figure 3).

Figure 3. Positions of 7 QTM cameras

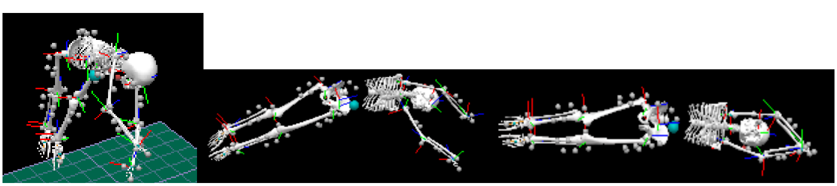
Results

After analyzing positions following ones are important for further analysis: moment of release (Figure 4a), moment of maximum height (Figure 4 b and Figure 4 c), arms crossing beginning (Figure 5a), regrasp with left hand (Figure 5b), and regrasp with right hand (Figure 5c). Temporal parameters for Moznik element are: time of full flight from release to left hand regrasp 0.74 s, and to regrasp with right hand 0.81 s; time from release to start initiation of turn is 0.47 s. Difference between left hand regrasp and right hand regrasp is 0.07 s. From analysis it is worth to note there is not symmetric regrasp with both hands, but there is a delay, however very short one that if human eye is not directly focused only on regrasp, it is hard to notice it, and this depends also on spectators view.



a b c

Figure 4. a - moment of release, b and c – maximum height different views



a b c

Figure 5. a – moment of crossing arms, b – regrasp with left hand, c – regrasp with right hand

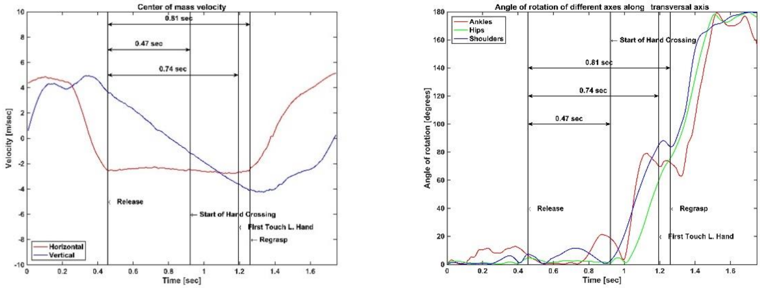


Figure 6. a – Body center of mass (BCM) velocity in x and y axis, b – joint angle in xyz axis

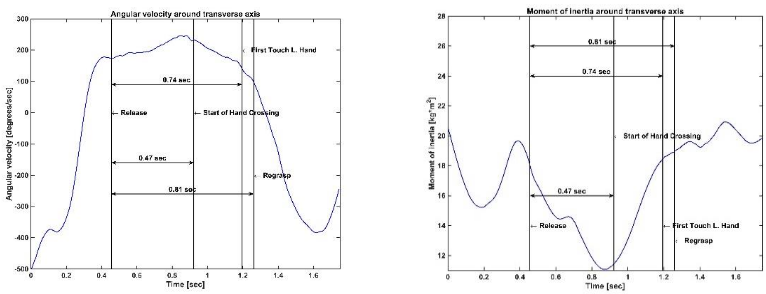


Figure 7. a – angular velocity around transverse axis, b – moment of inertia around transverse axis

Discussion

According to data from Atiković (2006) flight time of straight Tkatchev is between 0.64 s up to 0.76 s with an average of 0.70 s and our data show higher time is needed to perform Moznik element with an extra 180 degrees turn. Comparing Moznik element with stretched Tkatchev at release it is noted that velocity in y axis of BCM for Moznik is much higher 3.72 m/s than with Tkatchev 2.44 m/s – 3.01 m/, while horizontal BCM velocity is very similar (Čuk, Atiković, Tabaković 2009) with 2.49 m/s (Figure 6a). On Figure 6b are angles of ankle, hip and shoulder axis (axis left to right) in relation to high bar axis. Turning effect is made mostly according to Yeadon (1999) tilt turn, however it is important to notice that performing Moznik element while performing ½ salto forward, also counter turn direction movement in shoulder and hip axis before start turn was noticed, and Moznik element was also performed with combination of cat turn (Yeadon, 1999). Similar activity is noticed also with change of moment of inertia during flight around transverse axis, where with hip forward and side bending, shoulder adduction, subject lowers moment of inertia for 38% (from 18.03 to 11.06 kgm^2) (Figure 7b). Angular velocity around transverse axis (at release 176.6^0s^{-1}, and it is in middle range comparing with previous researches 147.8 – 229.3 $^0s^{-1}$, Qian, Cai, Tang and Zhou (1987), Čuk, Piletič (1995)) is related with higher moment of inertia at release and during the flight with lowering moment of inertia (Figure 7b), when calculating angular momentum it is very high, in moment of release 56.02 kgm^2s^{-1} and much higher again according to previous researches (34.1 kgm^2s^{-1} +-7,6SD, Kerwin, Irwin, Samuleson 2007). It is important to note that measured subject is much taller and heavier than subjects in previous research (Možnik, Hraski, M. and Hraski, Ž. (2013) and therefore is also cause for higher values of most variables. While it is very hard to notice the difference between hands in regrasp with human eyes, it is also hard to notice the angle of the turn finished with shoulders and hips. In the moment of both hands regrasp less than half of the turn is completed (angle shoulder axis horizontal bar 83.4^0, hip axis 77.4^0) and whole 180^0 turn is concluded by reaching the lower hang position.

Conclusions

Flight element Moznik in its original performance is highly demanding in sense of biomechanics kinematic values. By most of the variables comparing to stretch Tkatchev higher values for Moznik were found. However judges' evaluation of performance according to Code of Points in terms of one hand regrasp first and in amount of completed turn in moment of full regrasp is difficult, as only 178 Hz cameras revealed significant differences with the rules. From biomechanical perspective the higher difficulty value in Code of Points comparing to stretch Tkatchev is proper. Turning within Moznik is combination of cat and tilt turn (according to Yeadon (1999) description of turning mechanics), which in literature up to now was not described in practice. For coaches and gymnasts these results can serve as a guideline in technique and methods, how to initiate turn in the element and to focus them to upgrade performances to be completely in accordance with Code of Points.

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PERFORMANCE ANALYSIS OF WOMEN'S YOUTH BEACH HAND-BALL WORLD CHAMPIONSHIP 2017

Ohnjec Katarina, Kanjugović Iva, Hećimović Maja
Faculty of Kinesiology, University of Zagreb

Abstract

The aim of the research was to determine performance indicators of the winning and losing teams at the Women's Youth Beach Handball World Championship 2017 in Mauritius. The sample consisted of 56 matches played at the competition, i.e. 112 opponents from fourteen different national teams: Argentina, American Samoa, Australia, Chinese Taipei, China, Croatia, Hungary, Mauritius, Netherlands, Paraguay, Portugal, Spain, Thailand and Venezuela. The sample of variables consisted of the successfully and unsuccessfully executed technical and tactical handball elements in the attack and defence phases of the game (12 variables describing performance in offence- *successful/unsuccessful inflight shots, spin shots, a specialist's shots, direct goals, one-point shots, 6m shots* and three variables related to defence - *successful/unsuccessful goalkeeper's saves and blocks*). The Mann-Whitney U-test was used to determine the differences in performance variables between the winning and losing teams. The results showed statistically significant differences between the winning and losing teams for the following variables: successful inflight shots (0.98 ± 1.17 vs. 2.95 ± 3.08), successful spin shots (7.50 ± 5.73 vs. 11.16 ± 6.21), successful specialist shots (3.09 ± 2.55 vs. 4.79± 2.75), successful direct goals (0.43 ± 0.74 vs. 0.75 ± 0.86), and goalkeepers' effectiveness. An effective way of playing beach handball is created once the young female players meet both the attractive, specific requirements of the beach volleyball as well as the requirements of the classic indoor team handball. Successful spin shots, followed by classic jump shots efficiently performed by a player marked with a shirt in a different colour – a specialist were obtained as key factors in creating the performance of winning teams.

Key words: *technical-tactical elements, beach handball, women, performance analysis*

Introduction

Some sports such as volleyball, football, rugby, tennis have a version of their basic sports adapted to the sandy base. The well-known member of the Olympic sports family, indoor handball, or as some like to refer to it as "a decathlon with a ball", branched out into beach handball – "a younger brother", mainly played in summer (Rokavec, 2009). This sport began in 80's in Holland and Italy, countries with scarcely any handball tradition. Over time, sports federations showed growing interest for this popular sport, finally formalising the sport and issuing organizational regulations in 2002 and in 2005, the same was done by European Handball Federation (Lara Cobos, 2012). The philosophy of beach handball relies on the principles of „Fair Play" and it is based on the fact that the sport is very attractive – fast, fun and full of spectacular scenes and goals. However, a punishment given is directed against the players as individuals and not against the team (IHF, 2010).

The rules of the game are in line with efforts to make the game as attractive as possible, tight and interesting for both, players and spectators (Belančić & Marković, 2003). The playing court is 27 meters long and 12 meters wide rectangle, consisting of a playing area and two goal areas. The game consists of two halves, which are scored separately. Each half lasts 10 minutes. If each team wins a half, the result is a tie. As there must always be a winner, the "Shootout" ("One player against the goalkeeper") is used. A maximum of 4 players per team (3 court players and 1 goalkeeper) may be on the playing court (IHF, 2010). Specific technical and tactical elements which give an extra dimension to beach handball are reflected in: 1) awarding the goals: attractive goals are worth 2 points-inflight, spin shot, 2) the fact that attack takes place almost always with the advantage of an extra player 4:3 attack/defence 3) the role of the goalkeeper: a player (specialist) that creates the superiority in number of players, his/her goals are awarded two points and he or she initiates the attack, being in this way an additional player in position to perform spin shots form distance or to pass the ball in time for inflight shot (Gruić et al., 2011).

Beach handball is a demanding sport, with numerous moderate-to-high intensity displacements and actions, distributed intermittently throughout the game: long periods of low intensity activity interspersed by short bursts of high intensity (Pueo et al., 2017). In the beach handball, players spend most of their playing time on the playing area in the zone intensity load 90%-100% HRmax -39% playing time (Bělka et al., 2015). When temperature (T) and humidity (H) are high ($T > 27^{\circ}C$; $H > 80\%$) beach handball players are advised to consume fluids that correspond to about 1.5-2% of their body mass (Kaaras, Chryssanthopoulos & Diafas, 2007).

Beach handball competitions are organized on national, European and world level and they are supported by responsible sports federations. For the first time in 2017, the International Handball Federation (IHF) organized a beach handball competition for younger age categories (i.e. under 17) as a qualifying tournament for the Young Olympic Games that will be held in Buenos Aires in 2018.

The aim of this research was to establish probable differences between the winning and losing female teams participating in the Women's Youth Beach Handball World Championship in Mauritius in 2017 for situation related efficiency parameters' variables i.e. performance indicators. In this way, it would have been determined which variables of the game situation-related actions, performed by beach handball players, had had the greatest influence on a positive outcome of the game, i.e. victory in a beach handball game.

Methods

Participants

The sample consisted of 56 matches, that is, 112 opposing beach handball teams and their games performed during Women's Youth Beach Handball World Championship 2017 in Mauritius. Fourteen teams participated in the tournament (Argentina, American Samoa, Australia, Chinese Taipei, China, Croatia, Hungary, Mauritius, Netherlands, Paraguay, Portugal, Spain, Thailand and Venezuela). Situational efficiency was analysed for 56 winning and 56 defeated teams.

Measures

The method of notational analysis was used to collect data. The sample of variables consisted of frequencies of successfully and unsuccessfully executed technical-tactical elements of the game, performed during 56 beach handball matches in the phases of attack and defence. The 15 analysed variables were 12 indicators of game performance (situational efficiency) in the phase of attack and three indicators of game performance in the phase of defence (Table 1). Shots on goal, taken from diverse ways of execution, are presented as successful or completed (COMP) and unsuccessful (MISSED) shots. All data were officially collected by the IHF notators. The IHF official game statistics is posted at the official website www.ihf.info/.

Table 1. Sample of variables

Variable	Description
INFCOMP	successful catching of the ball and shooting on goal while the player is in the air (inflight)
INFMISSED	unsuccessful catching of the ball and shooting on goal while the player is in the air (inflight)
SPSCOMP	successful shot on goal after a body rotation through 360 ° about the longitudinal axis of air (spin-shot)
SPSMISSED	unsuccessful shot on goal after a body rotation through 360 ° about the longitudinal axis of air (spin-shot)
SPECOMP	successful shot on goal by a specially marked player (specialist)
SPEMISSED	unsuccessful shot on goal by a specially marked player (specialist)
DIGCOMP	successful direct shot on goal by a goalkeeper (direct goal)
DIGMISSED	unsuccessful direct shot on goal by a goalkeeper (direct goal)
ONPCOMP	successful shot on goal in a non-spectacular way (one pointer)
ONPMISSED	unsuccessful shot on goal in a non-spectacular way (one pointer)
6MCOMP	successful penalty throws
6MMISSED	unsuccessful penalty throws
GKCOMP	successful goalkeeper's saves
GKMISSED	unsuccessful goalkeeper's saves
BLO	Blocking shots on goal by jumping in the goal area

Statistical Analysis

Within the descriptive statistics, the following central and dispersion parameters of the observed variables were determined: Mean—arithmetic mean, SD—standard deviation, Min—minimum value, and Max—maximum value. To determine differences between the winning and losing teams in game performance variables, the Mann-Whitney U-test was used and the following were calculated: Σrwinn—sum of range values of the winning teams, Σrdef—sum of range values of the defeated teams, U—the value obtained by testing the statistically significant differences, Z—value for the U approximation for big samples, p—statistical error allowing the acceptance of the hypothesis where the difference is statistically significant. The level of statistical significance was set at p=.05.

Results

In Figure 1 and Table 2, the representation of shooting in different ways, expressed in frequencies, and the percentage of shares in the total ways of shooting are presented, separately for the winning and the defeated teams.

Table 2. Frequencies of different shooting with efficiency from all types of shooting

Variable	**WIN**			**DEF**		
	FR	%	COMP/MISS (%)	FR	%	COMP/MISS (%)
INF	213	13	163/50 (76,53%)	84	6	53/31 (63,10%)
SPS	875	51	613/262 (70,06%)	748	53	415/333 (55,48%)
SPE	369	22	264/105 (71,54%)	284	20	169/115 (59,51%)
DIG	51	3	41/10 (80,39%)	35	3	23/12 (65,71 %)
ON	115	7	81/34 (70,43%)	186	13	105/81 (56,45%)
6M	78	5	69/9 (88,46 %)	63	5	46/17 (73,02 %)
SUM	1701	100%	1231/470 (72,40%)	1400	100%	811/589 (57,93)

The descriptive statistical data of variables for the winning and the defeated young female beach handball teams and the results of the Mann-Whitney U-test are presented in Table 3. The following differences between the winning and the defeated teams in game performance variables were obtained for the variable successful inflight shots (INFCOMP), spin shots (SPSCOMP), specialist's shots (SPECOMP), and goalkeeper's direct goals DIGCOMP) and for successful (GKCOMP) and unsuccessful goalkeeper's saves (GKMISSED).

Table 3. Descriptive statistics of the performance variables registered for either the winning or losing young female beach handball teams and results of the Mann-Whitney U-test of the difference between the successful (winning) and unsuccessful (defeated) teams

Variable	**Winning teams**	**Defeated teams**	**Different from the winning team**		
	Mean ± SD (Min-Max)			**z**	***p***
INFCOMP	2.95 ± 3,08 (0-12)	0.98 ± 1.17 (0-5)	***+1.97***	***-3,74***	***0.00***
INFMISSED	0.91 ± 1.67 (0-8)	0.57 ± 0.99 (0-3)	+0.34	-0,55	0.58
SPSCOMP	11.16 ± 6.21 (1-29)	7.50 ± 5.73 (0-22)	***+3.66***	***-3,13***	***0.00***
SPSMISSED	4.79 ± 3.34 (0-16)	6.04 ± 4.00 (0-14)	-1.25	1,79	0.07
SPECOMP	4.79 ± 2.75 (0-11)	3.09 ± 2.55 (0-16)	***+1.7***	***-3,66***	***0.00***
SPEMISSED	1.91 ± 1.98 (0-9)	2.09 ± 2.15 (0-10)	-0.18	0,36	0.72
DIGCOMP	0.75 ± 0.86 (0-4)	0.43 ± 0.74 (0-3)	***+0.32***	***-2,16***	***0.03***
DIGMISSED	0.20 ± 0.55 (0-3)	0.21 ± 0.53 (0-3)	-0.01	0,29	0.77
ONPCOMP	1.46 ± 2.62 (0-14)	1.93 ± 3.56 (0-18)	-0.47	0,59	0.56
ONPMISSED	0.61 ± 1.33 (0-8)	1.48 ± 3.06 (0-14)	-0.87	0,95	0.34
6MCOMP	1.25± 1.88 (0-12)	0.84 ± 1.22 (0-6)	+0.41	-1,11	0.27
6MMISSED	0.16 ± 0.42(0-2)	0.30 ± 0.54 (0-2)	-0.14	1,14	0.25
GKCOMP	5.05± 3.71 (0-16)	3.25 ± 2.58 (0-10)	***+1.8***	***-2,63***	***0.01***
GKMISSED	14.76± 6.06 (3-30)	22.35 ± 4.91 (12-41)	***-7.59***	***6,09***	***0.00***
BLO	0.62 ± 0.99 (0-4)	0.42 ± 0.81 (0-3)	+0.2	-0,82	0.41

Discussion

The aim of the research was to establish differences between the winning and losing young female teams participating in the Mauritius Youth Beach Handball World Championship in the game performance variables. The first main finding of the research is that the winning teams had higher frequencies of shooting on the goal and higher efficiency of shooting in almost all variables. At Youth Beach Handball World Championship 2017 the winning teams made a total of 1701 shot on goal with efficiency of 72,40%. Out of which 51% were spin shots, performed with efficiency of 70,06%, 22% specialist shots with efficiency of 71,54%, 13% inflight shots with efficiency of 76,53%, 7% one pointer with efficiency of 70,43%, 5% penalty throws with efficiency of 88,46% and 3% direct shoots with efficiency of 80,39%. Almost identical presence of spin shots was found on the sample of the winning team of girls up to 16 years old (Gehrer, 2016), while the slightly larger representation of the inflight shots was obtained for this beach handball female population. The defeated teams made 1400 shots on goal with efficiency of 57,93%., which is 301 less than winning teams, with the following structure of the total number of shots: 53% spin shots (55,48% efficiency), 20% specialist shots (59,51% efficiency), 13% one pointer (56,45% efficiency), 6% inflight shots (63,10%), 5% penalty throws (73,02%) and

3% direct shoots (65,71%). The defeated teams of this championship demonstrate their tactical focus on specialist shots and the greater representation of the spin shots compared to the defeated teams of European Championship under 16 (Gehrer, 2016).

The second major finding is a set of game performance variables that are at the significance level, and are different with the winning and the defeated teams: successful inflight shots, spin shots, specialist's shots, goalkeeper's direct goals and successful and unsuccessful goalkeeper's saves. The results of this research on the beach handball junior team's effectiveness are in some segments consistent with those carried out on seniors. Differences in successful spin shots and inflight shots (Gruić et al., 2011) are important for juniors and seniors. As additional difference variables in junior category, the specialist's efficiency as well as direct goals of goalkeepers, occurred at statistically significant level.

Varieties in tactics displayed by the winning teams at this championship were directed, for the most part, towards creating offence positions that led to a two-point shot (a pirouette/ a 360°spin-shot, an inflight shot, specialist's shot and goalkeeper's shots). The successful offence might be mainly the result of the great individual abilities of the players, the most important of all being fast problem solving. In team sports, playing well means choosing the right course of action at the right moment and performing that course of action efficiently and consistently throughout the match (Gréhaigne, Godbout & Bouthier, 2001). A specialist is the player who makes the decision how to end the attack after winning the ball and does so predominantly in accordance with the activity of the opponent's defence players. In the final stage of the attack, the possible solutions for the specialist are rushing up and passing a ball to a teammate who performs a spin-shot, passing to a teammate who performs an inflight shot or shooting directly on the goal. Scoring or, alternatively, preventing the opposition from scoring, is also largely the result of the cumulative actions of other players and their co-ordinated group and collective actions (Rogulj, et al, 2011). Group tactics in beach handball rely on the performance of two players. Finalising the offense phase usually means co-operation of two players either through fast, precise and timely passing of the ball, which creates enough space for the player who receives the ball to perform a spin-shot or an inflight shot, or through the specialist's individual shot on goal. The decision which solution is the best depends on creativity of an individual who can recognise whether to shoot or pass the ball. The winning teams, mainly from Europe, based their physical abilities on the principles typical of beach handball and on the experience from the previous European championships. The training procedures of the winning teams had evidently included players' individual abilities improvement operators that were substantially more complex and more demanding with regard to coordination, as well as improvement of the co-operation between two players when performing final two-point shot, which proved to be the major factors of the efficiency in the matches at the Championship. Total winning team characteristics obtained suggest selecting procedures directed towards the characteristics of the successful senior teams. The losing teams were more frequently less efficient, that is, the opponent's defensive players and a goalkeeper easily recognised their intention and blocked it, probably because the attackers were looking for an individual solution more slowly, and primarily tended to execute two-point shots individually.

Statistically significant difference between the winning and losing teams indicates the goalkeepers' competence, in both, performing efficient saves as well as in scoring direct goals. The handball goalkeeper is a key element in the defense system of a team as he/she is the player in charge of avoiding goals by the opposing team (Espina-Agulló, et al., 2016). Technical-tactical performance of the goalkeepers in saving the goal in beach handball is related to efficient techniques for blocking different types of shots as well as to tactical co-operation of two defensive players, which results in decreasing the shooting angle and blocking the shots. The research results show that the role of the goalkeepers is not only the efficacy in saving the goal, but in the opening of the attack as well. When winning the ball, the goalkeeper has to make the best solution in accordance with the game situation: they either decide on a direct shot, or on a pass to a teammate who is in the best offensive position.

Future studies should follow trends and analyse individual sets of matches considering the tactical variations that occur because of the changes of ends. The sets differ a lot, since the players change positions and roles during the offence and defence phase of the game. It would also be interesting to analyse in detail the matches the result of which is a tie and the winner is determined by performing the shoot-out. The technical-tactical activities of goalkeepers in the shoot-out have changed considerably over the last few years, which also might be an interesting area for future study.

Conclusion

The analysed game performance indicators show in young female beach handball players that the winning teams are superior when it comes to variables related to offensive tactics, which means that the winners' attack play profile includes a successful implementation of all types of shots awarded with two points. The winning teams are also characterized by the goalkeepers' competence regarding both, effective saves, and the opening of the attack. The obtained factors could contribute importantly to the creation of training methods and programmes for beach handball players. In addition to improving the overall motor status, which predominantly depends on the development of high-speed and strength (Bykova et al., 2015), creating the training operators in accordance with key technical-tactical factors responsible for competitive performance would be preferred.

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DIFFERENCES IN THE TIMING OF BASEBALL SWING IN DIFFERENT CONDITIONS FOR HITTING OF ELITE BASEBALL PLAYERS IN THE CZECH REPUBLIC

Pravečková Petra, Matošková Petra, Süss Vladimír, Aubrecht Ivan
Charles University, Faculty of Physical Education and Sport, Prague, Czech Republic

Abstract

Purpose: The aim is to compare the timing of the baseball swing phases during the hitting against the pitcher, the pitching machine and the batting tee.

Methods: This is an experimental study in which we change the conditions for a baseball hitting (pitcher, pitching machine, tee). We analysed 5 elite baseball players in the Czech Republic. The monitored variables are the duration of selected phases of the swing. A high-speed camcorder (400Hz) was used to record the participants' action and their motion was analysed in 2D.

Results: When hitting from the batting tee, phase of the leg kick 0.118-0.128 s longer and upper body load (backswing) 0.082-0.115 s respectively. This can be caused by absence of variability of moving ball. Therefore, players are not limited by timing of the hitting motion directly dependent to a moving ball. When hitting against pitching machine the time of player's upper body load is 0.03 s longer compared to pitcher.

Conclusion: The differences in the duration of the different phases in the different hitting conditions can be caused by the absence of information sources from the pitchers motion, on which the batter responds. For practice during the hitting from batting tee, it is advisable to shorten phase of the leg kick and upper body load. And during the all designs it is advisable to put emphasis on the powerful bat-swing in training.

Key words: *Anticipation, pitcher, pitching machine, batting tee, visual perception.*

Introduction

The hitting is characteristic skill for baseball. The batter has the task of hit a pitching ball with a diameter of 74 mm and speed of 130-160 km/h (Higuchi et al, 2013). This requires not only good conditional prerequisites – to produce power with the use of reaction force and effectively to bring it into impact the ball with a bat, but also a good anticipation of the time and place to hit the ball (Katsumata, 2007). It is the timing of a swing with a bat to the expected ball contact point under the standard conditions defined by the baseball rules. The same movement task is played by batters of cricket and softball, and a similar task can be found, in tennis when the receiving player is playing an opponent (Carboch, Sùss, & Kočíb, 2014a).

The ball with speed 40 m/s (144 km/h) flights only 458 ms before it reaches home plate. Given that signal processing in the central nervous system and subsequent muscle activation required lasts about 150 ms, the batter only has the first 300 ms, during which he has to make a decision about whether, or when and where to swing (Higuchi et al., 2013). Therefore, it is very important to see the initial part of the ball trajectory (Carboch et al, 2010; Carboch et al, 2014b; Haller and Clark, 1990). The time of flight of the ball to home plate at different pitch velocities and the theoretical reaction time are given in Table1.

Table 1. Reaction time

Speed of pitch	[km/h]	96	112	128	144	152	160
Reaction time for contact with the ball	[s]	0.688	0.589	0.516	0.458	0.434	0.413

A hitting technique is a prerequisite for successful (regular) performance. For the accuracy of the hit, the timing of successive phases of motion is important. Various authors have dealt with the technique of the hitting (Higuchi et al., 2013; Katsumata, 2007, Van Suchs, 2013, Welch et al., 1995). Figure 1 provides simple overview of the partial motion sequences.

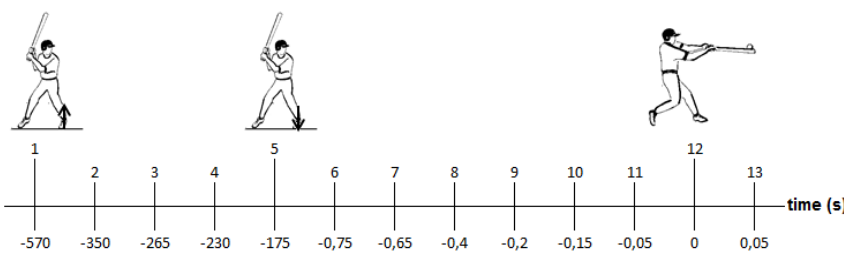

Figure 1. The sequence of events that occurred during the baseball swing (Welch et al, 1995, p. 199)

<u>Note:</u> Event sequence: 1) front leg (foot) lift, 2) maximum hip rotation, 3) maximum shoulders rotation, 4) maximum arm rotation, 5) putting the front foot back on the ground, 6) maximum hip rotation speed, 7) maximum speed of arm and shoulders

rotation 8) maximum linear speed of the bat, 9) maximum speed of the rotation of the bat, 10) maximum speed of extension in the right elbow, 11) maximum speed of the bat 12) contact with the ball 13) maximal speed of extension in the left elbow

In addition to hitting to standard live baseball pitching (real situation), drills are used in various training exercises. The basic means is hitting from a batting tee that is suitable from beginners to top players. Another means for hitting is a pitching machine that allows the hitting of a ball flying at high speed with a relatively high accuracy of the positioning of the pitch. However the pitching machine can affect movement coordination (Pinder, Renshaw, & Davids, 2009) as its use results in batters converging on nonspecifying variables, delaying the development and attunement to specifying variables (Araújo et al., 2007) so the use of the pitching machine should be limited (Carboch, Button, & Süss, 2012). The aim of the training should be that the batter hits the ball in all exercises with a similar timing of each phase of the hit as in a match. The aim is to compare the timing of the baseball swing phases during the hitting against the pitcher, the pitching machine and the batting tee.

Methods

The participants were 5 elite level baseball players in the Czech Republic (22.8 ± 2.7 years; 86.4 ± 11.4 kg; 187.2 ± 5.4 cm). All of them were right-handed hitters. Their baseball swing corresponds, despite individual techniques, to the generally known and used jet techniques. None of the test participants were affected by unfavourable health or fatigue and the same conditions were created for all players.

This is an experimental study in which we change the conditions for a baseball hitting. The monitored variables are the duration of selected phases of the swing. Baseline GeniCam piA640-210gc camcorder with a frame rate 400 Hz was used to record the motion. Figure 2 shows the experimental set-up as was previously done (Katsumata, 2007; Carboch, Sѝss, & Kočíb; 2013; Carboch, Sѝss, & Kočíb 2014a).

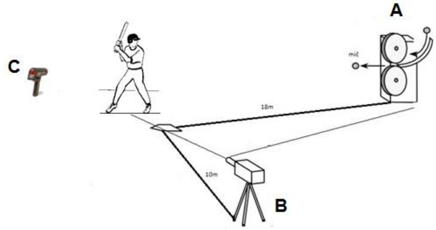

Figure 2. Measuring scheme (modified by Katsumata 2007, p. 31)

Legend: A – Pitching machine, B – High Speed camera, C – Radar

The monitored variables were the duration of the three phases of the hitting, which were bordered by critical points: (1) start of the weight transfer phase - the moment when the heel of the front leg blade interrupted the contact with the pad and the batter started the timing step; (2) the end of the timing step – the moment when the batter's front leg re-contacting the ground and ending the timing step; (3) the initiation of the swinging phase – the moment when the rear elbow started to move forward towards the ball; and (4) the bat-ball contact. Value zero on the timeline means the moment when the ball is released from the machine or from the hand by the pitcher. Critical points no. 1-2 mean the time of leg kick variable, no. 1-3 the time of upper body load (backswing) variable, no. 3-4 the time of swing variable. The participants were rated in 10 hits from the pitching machine, the batting tee and against the pitcher. The speed of all pitches was controlled by radar (Stalker Pro II) and average speed was 112.7 km/h.

Recordings from camcorder have been evaluated using the Dartfish 7 Team Pro computer program. The SPSS 5.0 software was used to calculate statistical significance (ONEWAY ANOVA, Test of Homogenity of Variances, Post Hoc Test - Tuckey HSD) and effect size (Cohen's d).

Results

Table 2 shows the overall results of the leg kick variable - from the moment the heel of the front leg has interrupted the contact with the ground until the batter's front leg reaches contact again. The results show an individually different performance of the leg kick in all monitored situations (the coefficient of the total variation reaches 26.3-43.8%). From the point of view of the individual timing of the leg kick, the highest stability shows the results of the hitting against pitcher (CV – 13.1-4.6%). On the contrary, large differences in the intra-individual performance were when hitting against a pitching machine.

Table 2. Results of the kinematic analysis of the leg kick

Leg kick									
	Tee			Pitcher			Pitching Machine		
Batter	Mean [s]	SD [s]	CV [%]	Mean [s]	SD[s]	CV [%]	Mean [s]	SD [s]	CV [%]
1	0,522	0.033	6.3	0.219	0.029	13.1	0.292	0.085	29.2
2	0.524	0.113	21.6	0.436	0.055	12.7	0.413	0.119	28.7
3	0.370	0.042	11.4	0.275	0.026	9.6	0.359	0.059	16.3
4	0.733	0.043	5.8	0.737	0.034	4.6	0.701	0.067	9.6
5	0.691	0.096	13.9	0.583	0.029	4.9	0.436	0.049	11.1
Mean	**0.568**	0.149	26.3	**0.450**	0.197	43.8	**0.440**	0.160	36.4

Legend: SD - standard deviation, CV coefficient of variation

The results of the kinematic analysis of the upper body load (the moment of end of the leg kick to the start of right elbow movement) in table 3 show, as in the case of a leg kick, to different inter-individual performance, the total coefficient of variation lies in the interval (24.1%-1%). From the point of view of intra-individual, the results are the most consistent when hitting against a live pitching (CV lies at a 3.3%-12% interval). The longest upper body load was used by the players during the hitting from the tee (0.582 s) and the smallest time when they hit against alive pitching.

Table 3. Results of the kinematic analysis of the upper body load

Upper body load									
	Tee			Pitcher			Pitching Machine		
	Mean [s]	SD[s]	CV [%]	Mean [s]	SD [s]	CV [%]	Mean [s]	SD [s]	CV [%]
1	0.507	0.032	6.4	0.228	0.022	9.6	0.339	0.097	28.5
2	0.433	0.105	24.2	0.473	0.057	12.0	0.497	0.138	27.8
3	0.349	0.056	15.9	0.299	0.033	11.2	0.369	0.063	17.2
4	0.687	0.038	5.6	0.732	0.024	3.3	0.752	0.140	18.6
5	0.602	0.083	13.7	0.604	0.034	5.6	0.545	0.093	17.0
Mean	**0.582**	0.140	24.1	**0.467**	0.192	41.0	**0.500**	0.183	36.5

Legend: SD - standard deviation, CV coefficient of variation

When analyzing the swing with a bat defined by the movement of the right elbow forward until the moment of contact with the ball we show (table 4) the relatively high homogeneity of the set (total coefficient of variation is in the range 13.8%-17.6%). From the point of view of the intra-individual in all three ways, the player achieves similar swinging variability during the hitting. The longest time values have been reached by the player when hitting against the pitching machine.

Table 4. Results of the kinematic analysis of the swing

Swing									
	Tee			Pitcher			Pitching Machine		
	Mean [s]	SD [s]	CV [%]	Mean [s]	SD [s]	CV [%]	Mean [s]	SD [s]	CV [%]
1	0.296	0.019	6.5	0.249	0.031	12.3	0.302	0.046	15.1
2	0.285	0.019	6.7	0.251	0.025	9.9	0.250	0.023	9.3
3	0.264	0.023	8.7	0.235	0.034	14.4	0.250	0.029	11.6
4	0.222	0.023	10.4	0.258	0.012	4.8	0.303	0.040	13.3
5	0.148	0.020	13.7	0.192	0.016	8.5	0.275	0.025	9.1
Mean	0.237	0.042	17.6	0.208	0.034	16.2	0.291	0.040	13.8

Legend: SD - standard deviation, CV coefficient of variation

Table 5 shows the significance levels for which a significant difference of means is applied. There was a large effect size of leg kick between the pitching machine and the tee (d > 0.8). The swing values for all three hitting conditions show large effect size and a significant difference in mean values using ANOVA.

Table 5. Statistical analysis

	Cohen's d			ANOVA		
	Upper body load	Swing	Leg kick	Upper body load	Swing	Leg kick
Tee-Pitcher	0.68	**0.96**	0.68	0.27	**<0.001**	**0.018**
Pitcher-Machine	0.18	**1.05**	0.05	0.629	**<0.001**	0.958
Machine-Tee	0.50	**0.96**	**0.83**	0.152	**<0.001**	**0.009**

Discussion

Our aim was mainly to compare the hitting against the pitcher and the pitching machine, but the third option - the tee - was also compared. We had two reasons to do so. The first is that a variable of flying ball is dropped off from the tee so the player does a swing without the necessity of timing of the hitting movement so that the trajectory of bat motion must intersect the flight path of the pitching ball at the right time. Which, according to Katsumata (2007), is the most important criterion for hitting that is not available on a tee. When hitting from a tee, players only perform a mechanical motion independent of other factors. The second reason is that the tee is the most used tool in baseball training. According to (http://colonialbaseballinstruction.com), the baseball swing is such a complex motion task, that if you can remove a significant variable from the process (flying ball), the ball is stationary, you can better focus on the mechanics. Our results show that all the participants have prolonged phase of the leg kick and the upper body load, when they hit from a tee. This can be explained by the fact that, when a flying ball variable is removed, the participants are not stressed and limited by the speed of the flying ball, and therefore they can afford longer performance of the leg kick and the upper body load.

If we compare the time sequence of the swing motion phases between the pitcher and the pitching machine conditions, we found a significant difference between these two performances, similarly to the research with the same focus in other sports sectors. For example, Pinder, Renshaw, & Davids (2009) say that the use of pitching machines leads to the removal of critical information sources, which it may result in a negative transfer of learning in specific development periods. This causes unintended changes in the coordination of movement, so it is first necessary to master the practical tasks that include some of the specific variables that are available in the competition (hitting against the pitcher) so that the players get to know with the specific variables available to support the performance.

It has been shown that limiting access to information, such as using pitching machines, will significantly affect the coordination of top cricket players' movements. Hitting against the pitcher and the pitching machine was compared, and significant differences in performance were observed in both cases. There were differences in the initiation of the cricket bats' upper body load. The batter who faced the bowling machine (BM) began upper body load (backswing) much earlier than when the facing the bowler (BM: 0.02 s v B: 0.12 s) (Renshaw et al., 2007).

Such research was realized in tennis and showed similar results. The hitting and the forehand stroke are a specific set of open skills, characterized by the task of giving the object (ball) an acceleration that allows the flight of the object to a certain distance (Kreighbaum, & Barthels, 1990). Carboch, Sǜss, & Kočíb (2014a) show that the timing of the receiving service in tennis flows varies with the serving machine use. The player behaves differently as compared to the server. The results of the study showed significant differences in movement initiation and the duration of the upper body load between performances of the stroke on the ball served by the machine and served by the live player. The average initial start time was 0.05 s longer for the live serving player compared to the serving machine. Players responded earlier when faced the service by a machine. In this study, the average flight duration was 1.1 s (113 km/h). The median for the initial movement was 0.38 s in the group on the serving machine, while in the serving player group, 0.41 s. The receiving player responded later when facing service by the live serving player, compared to the serving machine. The remaining time on the player's swing was only 0.66 to 0.68 s. The forward swing was almost the same in both cases.

In our research, we found similar results, where in the case of the hitting against the pitching machine, participants had a longer phase of upper body load on an average of 0.033 s than against the pitcher. However, the forward swing differed in each version. We think that this is due to the fact that, when hitting from a tee and against a pitcher, the motion is more ideal in the timing than against a machine where the swinging phase is due to "disillusionment" longer.

Thanks to prolongation of upper body load we deduce similar conclusions as Carboch, Sǜss, & Kočíb (2014a). They explain the change in the timing of the movement against the machine and the player by relying on the information associated with the flight only when the ball is served from the service machine, while in the case of a live pitcher, players are able to use more information from the pitcher's move. When they hit the pitching machine, the participants did not see/receive any information from the moving pitcher's move before pitching the ball, so they tried to start their movement as soon as possible and then reacted to the flying ball.

Similarly, other authors like Renshaw et al. (2007) showed that the differences in initiation of the cricket batter's movement faced by the pitching machine, the movements are initially initiated in comparison to the pitcher. It also appears that players use visual information from racket speed before contacting the ball and other movements during service (Shim, Carlton, & Kwon, 2006), so they can allow later initiation of movement in comparison of play against the machine.

This information from the movement of the opponent is obviously absolutely crucial and takes on the importance of experience. Goulet, Bard, & Fleury (1989) argue that top tennis players focus their view on the areas of the opponent's rocket and arm while the beginner's players focus on the ball. Notably, the initiation of the leg kick phase varied among the participants. Three of the participants started this phase before the ball was released by the pitcher, and the rest of them started at the moment of pitching the ball or just after it.

Shim, Carlton, & Kwon (2006) argue that relative racket and forearm movement provides important information for perceiving differences in co-ordination models between different types of strikes. This information is not available when using serving machines. Pinder, Renshaw, & Davids (2009) state that the serving machines change not only the information variables that are available until the ball is released, but also change the natural flight of the ball after its release and using ball machines affects movement coordination. Carboch, Button, & Süss (2012) recommend not to use the ball machine too often. In the case of baseball hitting, there is a pitcher´s movement, point of release of the ball by a pitcher, rotation of the ball by the pitcher, and other factors that the batter uses to improve hitting performance.

Conclusion

The differences in the duration of the different phases in the different hitting conditions can be caused by the absence of information sources from the pitchers motion, on which the batter responds. For practice during the hitting from batting tee, it is advisable to shorten phase of the leg kick and upper body load. And during the all designs it is advisable to put emphasis on the powerful bat-swing in training. The results of the study have their limitations because the research file was deliberately chosen from the top baseball batters in the Czech Republic. For this reason, the results refer only to the selected group of players and cannot be interpreted to other age categories.

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INTERNATIONAL COMPARATIVE ANALYSIS OF THE QUALITY OF STEREOPSIS AND CO-ORDINATION OF UPPER EXTREMITIES IN CHILDREN OF YOUNGER SCHOOL AGE IN THE CZECH REPUBLIC AND THE KINGDOM OF SPAIN

Salcman Václav, Valach Petr, Benešová Daniela, Vožehová Lucie
[1]*Department of Physical Education and Sport Science, Faculty of Education of the University of West Bohemia in Pilsen, Czech Republic*

Abstract

The goal of the presented research project is to compare the quality of stereoscopic vision and the quality of co-ordination abilities of upper extremities in children of younger school age in the Czech Republic and Spain. For testing the quality of stereopsis, the "FLY Stereo Acuity Test" (Vision Assessment Corporation 2012) was used. The quality of co-ordination of upper extremities was tested using the "Ball Tossing and Catching in the Lying Position" modified test (Měkota, Blahuš 1983). The research sample consisted of 153 children in the ages of 9-12 years, of which 59 children from the Czech Republic and 94 children from Spain. For the statistical processing of variables, the Statistica 6.0 program was used. Mutual differences between the groups were calculated using the Mann-Whitney U test. On the basis of the evaluation of the obtained data, the team of authors came to the following conclusions. There is a difference in the quality of stereoscopic vision ($p = 0 \leq \alpha = 0.05$) between Czech and Spanish children, and, at the same time, there is no difference in the quality of co-ordination of upper extremities ($p = 0.89 \geq \alpha = 0.05$) between Czech and Spanish children of younger school age.

Key words: *stereoscopic vision, stereo acuity test, co-ordination, upper extremities, motor skills, motor docility, younger school age, physical education.*

Introduction

Over the last 40 years, research in the field of human motor skills has been mainly focused on investigation of different aspects of fitness abilities. In contrast, there is a current need for a deeper and more detailed understanding of motor skills abilities, identifications and analyses of key factors of motor potential, and hierarchy of motor and somatic indicators. The breakdown of these factors depends on the possibilities of improved diagnostics, and the selection of appropriate means for the development of motor skills (Ružbarská, Turek, 2007). As further mentioned by the above authors, thanks to maturation of the nervous system, receptors, and musculoskeletal system, the time interval at the turn of the younger and older school age is very sensitive, and, in addition, the development of co-ordination abilities is partially influenceable in the course of ontogenesis of individuals. Also for this reason, it is possible to focus selectively on improvement of detected visual or co-ordination disorders. Vision, as a source of up to 85% of information about surroundings, plays a very important role in the quality of life of individuals.

The primary goal of this research study is to determine and compare the quality of stereopsis and co-ordination of upper extremities in children of elementary schools in the Czech Republic and Spain. The research aims to determine the differences between both nationalities, and define possible causes of the reduced quality of stereopsis, or co-ordination abilities. Within the framework of preventive measures, the objective of this research is to draw attention to the relevance of full-valued visual and motor functions both in day-to-day life and in the field of sports (spare-time and performance sports).

Co-ordination processes in relation to the quality of cognitive functions are described, for example, by Hirtz (2003). Visual and motor co-ordination at the neurological and psychological level has been discussed, for example, by Zago, Mcintyre, Senot, Lacquaniti (2009), the relationship of binocular vision and visual skills is described by Blake and Logothetis (2002), and connection between mobility and quality of stereopsis, or depth vision, is mentioned by Schreiber, Crawford, Fetter, and Tweed (2001). Spatial perception from the viewpoint of neurobiology is used also by Hubel (1989) in his studies. Other experts involved in visual and motor co-ordination are, for example, Rychtecký, Fialová (1995), Schmidt, Wrisberg (2000), Zwierko (2007), Munzert (2004), Meinel, Schnabel (2007), Mechling, Munzert (2003), Birklbauer (2006), or Hirtz (2003). Visual disturbances and related distorted co-ordination links are described, for example, by Grant et al. (2014), Schor (1991), Chapman at al. (2012), Loftus at al. (2004), Watt at al. (2003), or Suttle at al. (2011).

Methods

Research sample

The group of children consisted of fourth and fifth graders of primary schools in the Czech Republic and Spain. The research sample had a total of 153 tested persons (68 girls and 85 boys) in the age range of 9 to 12 years. As this is a comparative analysis, the whole sample was divided into two groups by nationality of children. The first group of 59 persons included children from the Czech Republic, who attend the 11th primary school in Pilsen. The second group of 94 persons included children from Spain, who attend the Colegio Público Fernando de Rojas primary school in the Province of Toledo. Both Czech and Spanish schools are public primary schools. The students were not subject to previous specialized selection focused on the determination of their level of physical activity. The selection of the tested persons was carried out on the basis of willingness and availability (Hendl 2004).

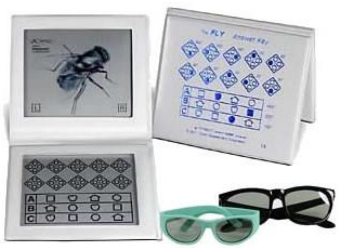

Figure 1. FLY Stereopsis Test. Source: http://www.argoequipment.com/product/stereo-fly-test

Test methods

Before commencing the test, the children completed a short initial history in their respective languages, asking their name, date of birth, visual disorders and their correction, as applicable.

In the course of testing at Spanish schools, a native speaker was always present and explained individual tests to children, including courses of these tests.

The FLY Stereo Acuity Test (Fig. 1) diagnoses binocular vision disorders (such as amblyopia, strabismus) in a quick and simple way. The author of the FLY Stereo Acuity Test is the American company Stereo Optical Co., Inc. (Chicago, IL, USA), and the validity and reliability of this test has been verified by study conducted, for example, by Prof. Ancona at al. (2014). Each person performs the test with vision correction (polarising spectacles are put over corrective eye-glasses/lenses) and identifies the “protruding” circles at ten patterns in the table, divided by the resolution sensitivity (scale 0-10). (Vision Assessment Corporation, 2012).

The “Ball Tossing and Catching in the Lying Position” test (Měkota, Blahuš, 1983) provides information on co-ordination of upper extremities and the level of motor docility. As standard, each tested person has 24 attempts. In view of the age of children, the number of attempts was reduced up to 10 in order to hold the attention of the persons for the entire duration of testing. Before commencing the test, each person had 2 test attempts. The person being tested lies on their back and tosses and catches the ball with their dominant upper extremity, and the ball must reach at least the height of the person being tested. We evaluate the number of valid attempts from 0 to 10.

Data evaluation

For the statistical processing of variables, the Statistica 6.0 program was used. Mutual differences between the groups were determined using the Mann-Whitney U test ($p < 0.05$). The alternative hypothesis claims that one of the populations tends to have higher values than the other. For the purposes of processing of descriptive statistics, Microsoft Office Excel was used. Measured parameters were interpreted on the basis of arithmetic mean, using tables and graphic representation. For a more detailed comparison, from a point of view of the different number of persons in individual groups, we used the percentage expression of the measured values.

Hypotheses

H1: "There is no difference in the quality of stereoscopic vision between Czech and Spanish children of younger school age."

H2: "There is no difference in the quality of co-ordination of upper extremities between Czech and Spanish children of younger school age."

Results

When comparing the specific values of stereopsis, great differences can be observed. In Czech children, with the increasing quality of stereopsis, the number of persons reaching higher values was also increased. As part of testing, 46% of children from the Czech Republic achieved the highest possible level. In Spanish children, however, we can see low values (levels of 1, 2 and 3) that do not appear in Czech children at all. Over 60% of persons from Spain reached levels of 5, 6 and 7 in testing, and only 7% of persons reached the level of 10 (see Fig. 2).

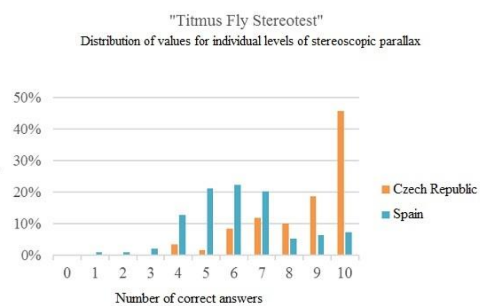

Figure 2. Distribution of stereopsis level values by country of origin. Source: internal

Figure 3 shows the number of valid attempts in the "Ball Tossing and Catching in the Lying Position" test across the entire tested sample. From the cumulative result, we can see that the test is highly demanding. 17 children out of a total of 153 did not catch the ball at all, or only once. In contrast, the number of persons who caught 9 or 10 balls, thus demonstrated their high quality of co-ordination of upper extremities is very low. Only three people achieved 9 or 10 valid attempts. The average of valid attempts within the entire sample of the tested persons is 4.44 caught balls. The Spanish children demonstrated a wider dispersion of the achieved valid attempts. During testing, the Spanish children reached all possible values, both the lowest ones (no valid attempt) and the highest ones (9 or 10 valid attempts). The Czech children demonstrated greater stability of performance. They moved in the range of 1 to 8 valid attempts, but they did not reach the extreme values like the Spanish children.

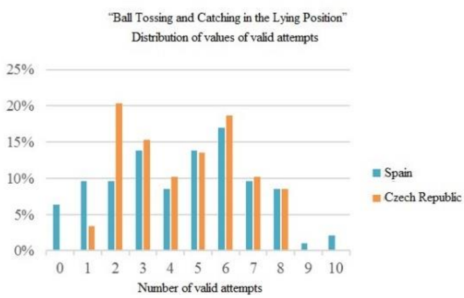

Figure 3. Distribution of values in the motor test by country of origin. Source: internal

Evaluation of hypotheses

H1: "There is no difference in the quality of stereoscopic vision between Czech and Spanish children of younger school age."

On the basis of the Mann-Whitney U test results (Table 1), which tests differences in the samples, the H1 hypothesis was refused, and the alternative hypothesis was accepted: "There is a difference in the quality of stereoscopic vision between Czech and Spanish children of younger school age." ($p = 0.00$); ($p \leq \alpha \leq 0.05$).

Table 1. The Mann-Whitney A test for comparison of stereopsis and motor activity in Czech and Spanish children. Source: internal processing of the Statistica 6.0 program.

Mann-Whitney U Test by variable GROUP									
Group 1: CZ Group 2: ESP									
	Rank Sum	Rank Sum				Z		Valid N	Valid N
	CZ	**ESP**	**U**	**Z**	**p-level**	**adjusted**	**p-level**	**CZ**	**ESP**
STEREOPSIS	6150.5	5325.5	954.5	6.67	0.00	6.75	0.00	58	93
MOTOR SKILLS	4414.5	7061.5	2690.5	0.03	0.98	0.03	0,98	58	93

In contrast to assumptions, the hypothesis was disproved. It has been demonstrated that there is a statistically significant difference in the quality of stereoscopic vision between Czech and Spanish children of younger school age. In view of the same age of persons, therefore, the same level of their development, we assumed the identical quality of stereopsis in the whole sample. For the sake of completeness, we are attaching the mutual ratios of the person results in the stereopsis test generated by Statistica 6.0. for the Czech and Spanish groups (see Fig. 4).

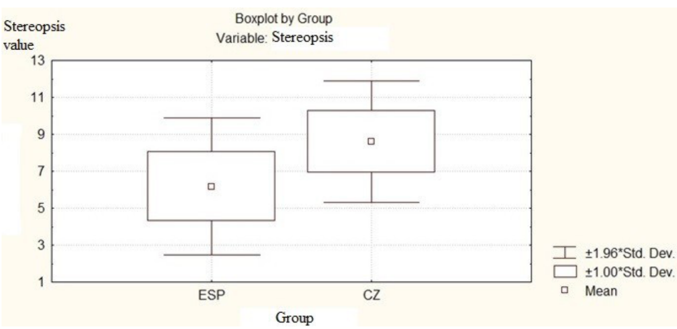

Figure 4. Mutual ratios of the person results in stereopsis test for the Czech and Spanish groups. Source: internal processing of the Statistica 6.0 program.

H_2: "There is no difference in the quality of co-ordination of upper extremities between Czech and Spanish children of younger school age."

On the basis of the Mann-Whitney U test results (Table 1), which tests differences in the samples, the **H_2** hypothesis was accepted: "There is no difference in the quality of co-ordination of upper extremities between Czech and Spanish children of younger school age." ($p = 0.98$); ($p \leq \alpha \leq 0.05$).

According to assumptions, it has been demonstrated there is no statistically significant difference in the quality of co-ordination of upper extremities between Czech and Spanish children of younger school age. For the sake of completeness, we are attaching the person test results in the "Ball Tossing and Catching in the Lying Position" test generated by Statistica 6.0. for the Czech and Spanish groups (see Fig. 5).

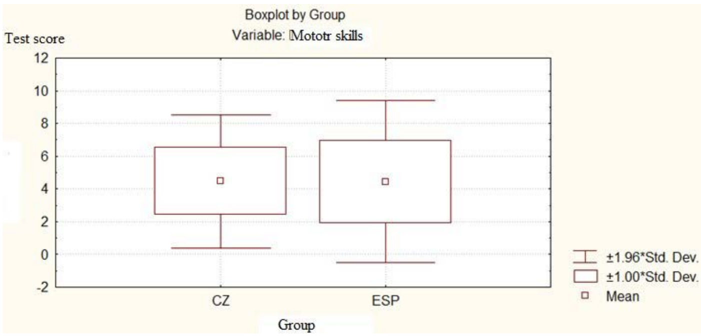

Figure 5. The mutual ratios of person results in the motor activity test for the Czech Republic and Spain. Source: internal processing of the Statistica 6.0 program.

Discussion

The children were selected on the basis of their willingness and availability (Hendl 2004), therefore, this is not a representative sample, and this research cannot be generalized. The tests were carried out in the Czech Republic and Spain under identical conditions, but the research could be influenced by some of the factors that can´t be influenced (such as fatigue or emotional condition of the tested persons).

The FLY Stereo Acuity Test was used for testing of stereoscopic vision at the level of 400 "-20". In the quality of spatial vision, the Spanish children showed significantly worse results than the Czech children. The arithmetic mean of the measured values for Czech children was $\bar{x}$ = 8.63, and the arithmetic mean for Spanish children was $\bar{x}$ = 6.17. The values of stereoscopic parallax equivalent to 30"-15" can be considered excellent (Cybersight, 2016), and in this case, it was equivalent to levels of 8, 9 and 10. 40% of the persons across the entire test sample achieved the said values, namely 75% of Czech children and only 19% of Spanish children. With regard to the fact that stereoscopic vision is not a frequent topic of research work, we have not available similar work, which uses the same methods and research sample, in order to compare the results obtained using the "FLY Stereo Acuity Test".

In the “Ball Tossing and Catching in the Lying Position” test, the Czech and Spanish children achieved almost identical results, which were compared on the basis of arithmetic means. The arithmetic mean for Czech children was $\bar{x} = 4.49$, and the arithmetic mean for Spanish children was $\bar{x} = 4.41$. On the basis of the results at a significance level of $\alpha = 0.05$, we can state that this is not a statistically significant difference in this case.

It is necessary to take a moment to think about the fact why the results of Czech and Spanish children in the “Ball Tossing and Catching in Lying Position” test are practically identical, but the stereopsis test results are so different, even if both tests are linked logically. In the course of stereopsis testing, we observed a great lack of concentration and distraction of Spanish children. We had to repeatedly stress that they should concentrate and deliver the best possible performance. It was interesting, however, that the Spanish children carried out the motor ability test with enthusiasm and concentration. These facts led us to make a deeper analysis of the causes. It can be assumed that the answer lies in the different concentration and motivation of students in both tests, and both factors have likely their origin in different school systems. While in Czech children, emphasis is placed on the immediate concentration and performance, the Spanish school system prefers a freer, playing form of teaching. There is a presumption that these facts explain why the Spanish children were able to perform relevant performance in the motor ability test, while in a more complicated stereopsis test, which was time consuming, difficult, and therefore not motivating, their performance was not so good.

Conclusion

We performed a statistical evaluation of the obtained data. On the basis of this evaluation, we refused the H1 hypothesis. There is a statistically significant difference in the quality of stereoscopic between Czech and Spanish children. The H2 hypothesis was confirmed. By evaluating the data, we have showed that there is no statistically significant difference in the quality of co-ordination of upper extremities between Czech and Spanish children. Refusal of the H1 hypothesis can be attributed to the lack of concentration and loss of motivation of Spanish children in the course of stereopsis testing.

On the basis of experience to date, we recommend to perform testing with children individually, and with the maximum limitation of interfering factors. In view of the more objective evaluation of the quality of visual functions and motor skills and abilities, we consider as appropriate to include the history of sports and physical activity. The research results with comments and recommendations were sent to participating primary schools and to parents too. Ophthalmological examination was recommended for children showing significantly below-average values of stereopsis.

On the basis of the results and experience of this research project, recommendations for practice can be divided into the below 2 main areas. 1. Preventive - In the early diagnosis of disorders of visual functions by ophthalmologists, appropriate medical therapy (visual rehabilitation) can be applied in children, and, some disorders may be gradually relieved, or completely removed. Specific examination of children by the stereopsis test directly at schools can also reveal the above-standard values of simple binocular vision, and this can be vital information in the decision-making process, for example, for future sports and physical activity orientation of children. 2. Nationally specific - As mentioned in the discussion section, we are of the opinion that the results of the selected tests in international projects can be influenced, for example, by differences in the methods of approach to education systems, or established national practices in different countries. Generally speaking, for the successful course of international research, it is necessary to integrate the above-mentioned factors into the project preparation, and, subsequently, to adjust the research methods.

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RELATION BETWEEN THE SPEED OF FRONT CRAWL SWIMMING WITH EITHER THE ARMS ONLY OR FLUTTER-KICKING IN GROUP OF JUNIOR CATEGORY MALE SWIMMERS

Šťastný Jan, Motyčka Jaroslav, Bátorová Michaela
Brno University of Technology, Centre of Sport Activities, Brno, Czech Republic

Abstract

The results of the researches aimed to assess the impact of flutter-kicking (FK) and swimming with the arms only (SAO) on front crawl swimming (FCS) speeds often differ in their results. They agree with the fact that FK is an important part of FCS, but they differ in the proportion at propulsion forces of swimming and the impact of speed on swimming. With the help of the Tachograph measurement system, we verified the possibility of evaluating their relation on the sample of junior category male swimmers.

For our evaluation, we have chosen data of 10 swimmers who were at the age of 16 years at the time of measurements. We used the Tachograph measuring system. The swimmers were asked to swim 50 metres, initially only with the help of FK, subsequently using their arms only, and finally FCS. We used data from the first 25 meters of the track to eliminate the effect of push off and turn.

At the measured section swimmers reached mean speed of 1,637 ± 0,079 $m \cdot s^{-1}$ during swimming with FCS, it was 1,399 ± 0,0603 $m \cdot s^{-1}$ when they SAO, and with FK their mean speed was 1,082 ± 0,067 $m \cdot s^{-1}$. We found out that swimming velocity when moving without FK is lower by 0,238 $m \cdot s^{-1}$ ± 0,049 $m \cdot s^{-1}$ compared to FCS.

We focused on the relation between the speed of front crawl swimming with either the arms only or flutter-kicking. The results of our measurements showed that front crawl swimming speed highly correlates with swimming with the arms only ($r = 0.83$). We did not find any statistically significant relation between the results of flutter-kicking and front crawl swimming ($r = 0.15$). However, flutter-kicking contributes to higher speed during front crawl swimming at least by reducing the drag forces of water of the swimmer because the measured speed of front crawl swimming is higher than the swimming speed reached with the arms only.

Key words: *tachograph, speed, efficiency, frequency, freestyle, propulsion, drag*

Introduction

The aim of this study was to determine relation between the speed of front crawl swimming with either the arms only or flutter-kicking with using *Tachograph* measuring system.

The results of the researches aimed to assess the impact of flutter-kicking (FK) and swimming with the arms only (SAO) on front crawl swimming (FCS) speeds often differ as it can also be seen in studies by Silveira, de Souza Castro, Figueiredo, Vilas-Boas and Zamparo (2016), Gourgoulis, Boli, Aggeloussis, Toubekis, Antoniou, Kasimatis, Vezos, Michalopoulou, Kambas and Mavromatis (2014), and Gatta, Cortesi and Di Michele (2012). They agree with the fact that FK is an important part of FCS, but they do not agree on the proportion of propulsion forces of swimming and the impact of speed on swimming.

Čechovská and Miler (2008) state that the propulsive force is generated primarily by upper extremities, whereas lower extremities largely help with stabilization and balance. The activity of lower extremities has the character of alternating wave oscillation. Movements come from the hip joint. According to Counsilman (1974), the effect of lower limbs is more important in sprints than in long-distance swimming which is characterized by lower frequency of leg kicking.

With the help of Tachograph measurement system, we verified the possibility of evaluating relations of variables on the sample of junior category male swimmers.

Methods

For our evaluation, we have chosen data of 10 competitive swimmers who compete at a national level. They were 16 years old at the time of the measurements. Their best performances achieved in 50m front crawl swimming in a short course (25 m) swimming pool converted to swimming speed (v_{max}) were 1,916 ± 0,116 $m \cdot s^{-1}$ on average. All the swimmers used the six-beat kick technique per arm cycle.

We used the Tachograph measuring system for recording swimming speed together with synchronous video recording (Motyčka, Vlk, Krejsa, Ondroušek & Životský, 2009).

After 15 minutes of stretching and warm-up swimming the swimmers were asked to swim 50 metres, initially only with the help of FK, subsequently using their arms only (SAO), and finally with interplay (FCS). The swimmers had a 5minute rest between each of the measurements.

We used *the SwimDataViewer* software (Krejsa, Ondroušek, Motyčka & Šťastný, 2009) to evaluate the data from the first 25 meters of the track. To eliminate the effect of push off and turn, we only analyse the data gained after a swimmer surfaces.

We set the second stroke of the arm after surfacing as the interval for each swimming section. At this point, the speed of the swimmer is not influenced by the start, turns, and measuring devices anymore. The interval ends at the distance of at least 2m from the end of the swimming pool (Šťastný, Motyčka, Bátorová & Pašek, 2016; Šťastný, 2016). With the help of our software we have calculated and compared values and correlations of the following variables: mean speed ($m \cdot s^{-1}$), stroke rate (Hz), efficiency, and ratio of mean speed achieved during measurements to maximum mean speed. This ratio is converted into percentage.

Results

At the measured section swimmers reached mean speed of $v_{fcs =}$ 1,637 ± 0,079 $m \cdot s^{-1}$ during swimming with FCS, it was v_{sao} = 1,399 ± 0,0603 $m \cdot s^{-1}$ when they SAO, and with FK their mean speed was v_{fk} = 1,082 ± 0,067 $m \cdot s^{-1}$. We found out that swimming velocity reached by moving without FK is lower by 0,238 $m \cdot s^{-1}$ ± 0,049 $m \cdot s^{-1}$ compared to FCS (Table 1).

Table 1. Mean values and standard deviations of speed, frequency and efficiency

	AVG	SD
Personal best speed (v_{max}) ($m \cdot s^{-1}$)	1,91560	0,115601
Speed FCS (v_{fcs}) ($m \cdot s^{-1}$)	1,63710	0,078875
Speed SAO (v_{sao}) ($m \cdot s^{-1}$)	1,39910	0,060304
Speed FK (v_{fk}) ($m \cdot s^{-1}$)	1,08210	0,067232
v_{fcs} - v_{sao} ($m \cdot s^{-1}$)	0,23800	0,044791
Frequency of arms strokes during FCS (Hz)	0,85849	0,062180
Frequency of flutter-kicking during FCS (Hz)	2,59424	0,194402
Frequency SAO (Hz)	0,79235	0,063333
Frequency FK (Hz)	2,44949	0,175542
Efficiency FCS	0,98216	0,008646
Efficiency SAO	0,96012	0,024782
Efficiency FK	0,97234	0,007493

Note.
FCS – Front crawl swimming;
SAO – Swimming with arms only;
FK – Flutter kicking

Table 1 shows that the swimmers achieved top swimming efficiency (minimum speed fluctuations) during front crawl interplay (FCS) and subsequently while leg kicking (FK). Efficiency was lower when they used arms only while swimming (SAO).

Table 2. Correlation between variables (speed, frequency and efficiency)

var.	v_{max}	v_{fcs}	v_{sao}	v_{fk}	f_{fcs}	f_{sao}	f_{fk}	n_{fcs}	n_{sao}	n_{fk}
	Correlation; p < ,05000; N=10									
v_{max}	1,0000	0,7775	0,8644	-0,0871	0,6413	0,1844	-0,1528	0,3273	0,4616	0,2115
v_{fcs}	0,7775	1,0000	0,8254	0,1472	0,7267	0,4420	-0,0984	0,2660	0,6012	0,2954
v_{sao}	0,8644	0,8254	1,0000	0,1983	0,4868	0,2060	-0,1050	0,0483	0,5011	0,5259
v_{fk}	-0,0871	0,1472	0,1983	1,0000	0,1191	0,4574	0,3901	-0,3448	0,2408	0,1228
f_{fcs}	0,6413	0,7267	0,4868	0,1191	1,0000	0,7186	0,2914	0,4127	0,3755	0,0890
f_{sao}	0,1844	0,4420	0,2060	0,4574	0,7186	1,0000	0,3372	0,1550	0,5092	0,0698
f_{fk}	-0,1528	-0,0984	-0,1050	0,3901	0,2914	0,3372	1,0000	0,3799	-0,2421	0,4229
n_{fcs}	0,3273	0,2660	0,0483	-0,3448	0,4127	0,1550	0,3799	1,0000	-0,0047	0,1417
n_{sao}	0,4616	0,6012	0,5011	0,2408	0,3755	0,5092	-0,2421	-0,0047	1,0000	0,0595
n_{fk}	0,2115	0,2954	0,5259	0,1228	0,0890	0,0698	0,4229	0,1417	0,0595	1,0000

Note.
v_{max} - Personal best speed
fcs – Front crawl swimming
sao – Swimming with arms only
fk – Flutter kicking

Discussion

Prior to processing some other data, we verified whether the performances achieved by the swimmers during our measurements met our requirements. The measured swimming speed (v_{fcs}) reached 85.6% of the personal maximum mean speed achieved by the swimmers during races (v_{max}). The difference is caused by the influence of starts and turn effects as swimmers reach the highest speeds after starts and turns. Moreover, the swimmer is limited by the measurement method in these parts of the track. According to the results by Šťastný (2016), swimming speed reached during measurements should come up to at least 84% of the maximum. Our results live up to these expectations. At lower average speeds, measurement results are inaccurate.

We also compared the differences in stroke frequencies during front crawl swimming technique (interplay), flutter-kicking (FK) and swimming with arms only (SAO). During FCS (interplay) frequency of strokes was higher both in arms and legs. Frequency of strokes was lower by 5.6% during SAO swimming and it was lower by

7.3% while using legs only compared to interplay. We anticipated this difference and it should not significantly affect our results.

We found out that speed reached during SAO was lower by 14.3% compared to FCS. This result corresponds with the findings made by Gourgoulis et al. (2014), who states that the difference in speeds amounts to 13%. The difference is not caused by the propulsive force of FK according to the author, but largely by the reduction of body's inclination (reducing resistive drag).

Our results (Table 2) also do not confirm the statistically significant correlation between the variables of FCS speed (v_{fcs}) and FK (v_{fk}) variables ($r = 0.147$). These variables are not interdependent. It has not been proved that higher speed achieved during FK swimming affects the overall swim speed. On the contrary, we have detected a high level of correlation between variables v_{fcs} and v_{sao} ($r = 0.825$). The work of the arms is, according to our results, the main factor responsible for propulsion power and achieved speed during front crawl swimming. We have also detected a significant relation ($r = 0.7267$) between FCS swimming speed and stroke rate (f_{fcs}).

The relation between the efficiency of swimming technique and the FCS speed was not statistically significant within the monitored group. This result corresponds with our earlier research conducted in men´s category on a sprinter track (Šťastný & Motyčka, 2015).

The factors that we have not dealt with in our study but which will affect the results, are primarily anthropometric parameters.

On the ground of our results, we cannot confirm the findings made by Gatta et al. (2012). The methodology and focus of our research were different. We only focused on swimming with maximum effort and we did not examine relations of variables at different speeds of swimming. The author states that the influence of flutter-kicking on propulsion power increases at lower speeds of swimming, especially on longer tracks. Gatta states that the largest contribution of leg kicking occurs when the swimming speed is around $1.27\ m \cdot s^{-1}$.

On the other hand, Silveira et al. (2016) concludes at his study that the contribution of leg-kick action in the front crawl stroke increases with swimming speed. We detect the relation between stroke frequency and swimming speed in FCS in our research (Table 2) ($r = 0.727$), but it cannot be confirmed in SAO ($r = 0.206$).

Conclusion

We focused on the relation between the speed of front crawl swimming with either the arms only or flutter-kicking. The results of our measurements showed that front crawl swimming speed highly correlates with swimming with the arms only ($r = 0.83$).

We have not found any statistically significant relation between the results of flutter-kicking and front crawl swimming (r = 0.15). However, flutter-kicking contributes to higher speed during front crawl swimming at least by reducing the drag forces of water of the swimmer because the measured speed of front crawl swimming is higher than the swimming speed reached with the arms only.

Our research shows that the mean speed of SAO is lower by 14.6% in comparison with the mean speed achieved by FCS.

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MOBAK 3 – PRESENTATION OF A TEST BATTERY OF BASIC MOTOR COMPETENCIES AND SELECTED RESULTS OF THE CZECH REPUBLIC AND SWITZERLAND

Vrbas Jaroslav
Masaryk University, Faculty of Education, Brno, Czech Republic

Abstract

The aim of the paper is to introduce the MOBAK 3 basic motor competence test battery. The results obtained are interpreted using a unified methodology published in the pilot measurement of pupils in Switzerland (Herrmann, C., & Seelig, H., 2016). Basic used method for this measurement was test battery MOBAK 3. In the Czech Republic, the total amount of students was 302 (n=302, 133 boys and 169 girls). In Switzerland was measured 323 students. The same statistical methods were used to express the results. In most cases, there is a strong correlation between the Czech and Swiss results. We can say, that the chosen disciplines are similarly challenging between both countries. The students from Switzerland achieved significantly greater results in the discipline „Bouncing the basketball“. In most cases, students from the Czech Republic finished with better results from area Self-movement items. In both states the results have been similar in most items. Students in both countries achieved bad results in items „Throwing at the target" and „Rope skipping“. Altogether, we can say that the test battery MOBAK 3 is useful in both areas. We think that it would be great to discuss certain adjustments of some tests.

Key words: *MOBAK 3, Object-movement, Self-movement, locomotion, basic motor competencies, basic motor qualifications, third grad*

Introduction

In order to record the effects of physical education, it is necessary to develop assessment instruments that are also valid and practical for this subject. The test battery, which measures basic motor competencies in primary school, is an assessment instrument designed for this purpose. MOBAK-3 test battery is designed for third graders (Herrmann & Seelig, 2015).

The central task of Physical Education (P. E.) is the qualification of students to actively take part in the culture of sports and exercise. This contributes to the development of a physically active lifestyle. A prerequisite for this is the availability of basic motor competencies (Herrmann & Gerlach, 2014). For instance, there is a broad consensus among subject experts and teachers that all students need to be able to handle a ball safely in order to play ball. It is more difficult for children who do not have these competencies to participate in sports clubs or even play with their classmates on the playground. These practices are an enrichment for most people's cultural lives and an important part of active mobility and a healthy lifestyle (Kurz, Fritz, & Tscherpel, 2008).

Basic motor competencies can be defined as motor performance dispositions which can be developed from situation specific requirements and which can serve as an accomplishment strategy for requirements in the culture of sports and exercise.

The aim of the paper is to introduce the MOBAK 3 basic motor competence test battery. We present selected data measured by pupils of third grade at the available primary schools within the Czech Republic in Brno and its surroundings compared to Switzerland. The results obtained are interpreted using a unified methodology published in the pilot measurement of pupils in Switzerland (Herrmann, C., & Seelig, H., 2016).

Methods

Basic used method for this measurement was test battery MOBAK 3. Seven elementary schools from Brno and its surrounding agreed to cooperate. Sixteen third classes took part in the measurement. In the Czech Republic, the total amount of students was 302 (n=302, 133 boys and 169 girls) in all disciplines. In Switzerland the number of measured students reached the number 323. The same statistical methods were used to express the results.

In the construction of the test battery, we differentiate between basic motor competencies (MOBAK), which are not directly observable, and basic motor qualifications (MOBAQ, Kurz et al., 2008), which are observable. The competence structure model illustrates the relationship between basic motor qualifications and basic motor competencies. This allows the "indirect" acquisition of basic motor competencies through basic motor qualifications (Herrmann & Gerlach, 2014).

The test items for the acquisition of basic motor qualifications were developed on the basis of normative pedagogical discussions. The main question was: What should a child at a certain age be able to perform in order to take part in the culture of sports and exercise (Kurz et al., 2008)? The final arrangement of the test battery is the result of a wide selection of potential test items compiled and discussed in several expert discussions. The criteria for item construction were gender-specific test fairness as well as feasibility and age-appropriate item design. The test items measure eight basic motor qualifications which can be assigned to the two basic motor competencies “object movement” and “self-movement.” The basic motor competency “object movement” involves the basic motor qualifications: throwing, throwing & catching, bouncing, and dribbling. They are developed from requirements that include handling balls and serve as an accomplishment for requirements in various ball sports. The basic motor competency “self-movement” involves the basic motor qualifications balancing, rolling, rope skipping and variably moving. They are developed from requirements that include handling the entire body and serve as an accomplishment for requirements in gymnastics or athletics (Kačerovská, 2017).

Each child has six attempts at each test items (Throwing” and Throwing & catching). Each hit or passed attempt is recorded. 0–2 hits or passed attempts are assessed with 0 points, 3–4 hits or passed attempts with 1 point, and 5–6 hits or passed attempts with 2 points. Each child (MOBAQ test items Bouncing, Dribbling, Balancing, Rolling, Rope skipping, and Moving variably) has two attempts at fulfilling the task. These test items are dichotomously scaled (0 = failed, 1 = passed). The amount of times passed is recorded (both attempts failed = 0 points, one attempt passed = 1 point, both attempts passed = 2 points). The data can be evaluated on the level of MOBAQ test items as well as on the level of MOBAK areas. The MOBAQ test items can be evaluated separately due to their point scores (0–2 points). This also allows teachers to match the teaching content with the children’s performance levels.

The MOBAK areas are calculated as the sum of the results of the four MOBAQ test items. A maximum total of 8 points can be achieved for each area (4 test items x 2 points). On the basis of the scoring system (0 to 8 points), the level of a student’s basic motor competencies can be determined separately.

Results

The MOBAK 3 results were processed in Microsoft Excel and STATISTICA 12 and the selected graphs are simplified outputs for these two programs.

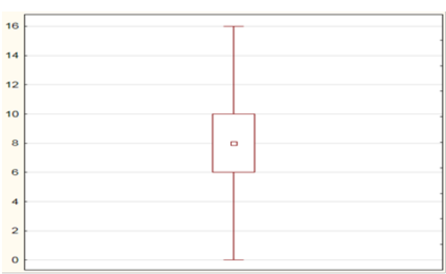

Figure 1. Overall rating of MOBAK 3 for the Czech Republic

From the chart (Fig. 1) we can see that both the minimum and the maximum result have been achieved. We also see that the greatest number of measured results is in the range of 6 to 10 points and the median is 8. There are no extremes in the case of the overall evaluation.

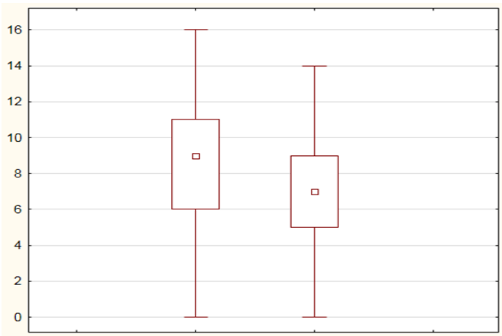

Figure 2. Overall rating of MOBAK 3 by gender (boys and girls)

On this graph (Fig. 2), we see that the only value that is identical for both boys and girls is the deviation avalanche at 0. It is also seen that the middle 50% of the boys are in a point range of 6 to 11 points and their median is 9. In girls, their mean 50% is in the range of 5 to 9 points and their median is 7.

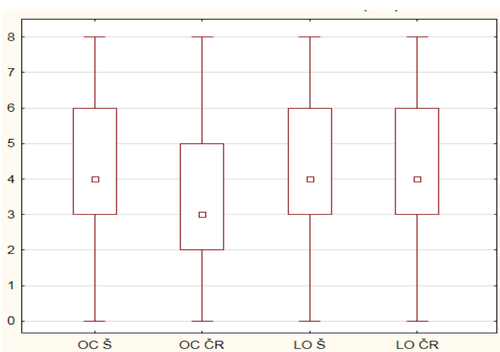

Figure 3. Boxed graph of both MOBAK 3 regions, comparison between the Czech Republic and Switzerland

Legend: OC Š - Object control Switzerland, OC ČR - Object control of the Czech Republic; LO Š - Locomotion Switzerland, LO ČR - Locomotion of the Czech Republic

From the previous chart (Fig. 3), it is very easy to see that Swiss pupils were more successful in the items in which they were working in the area Object control. In Locomotion, the results are almost identical.

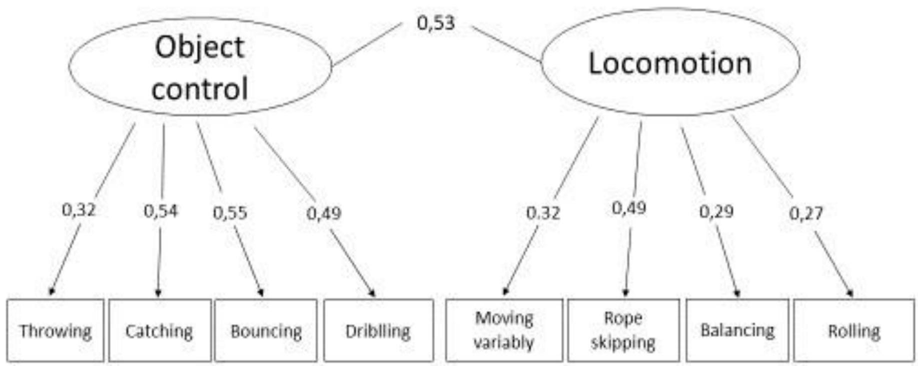

Figure 4. Mutual correlations between disciplines and their entire group and also between groups – Czech Republic (Kraus 2017)

From the figures above it can be seen that in most cases there is a strong correlation between Czech and Swiss results.

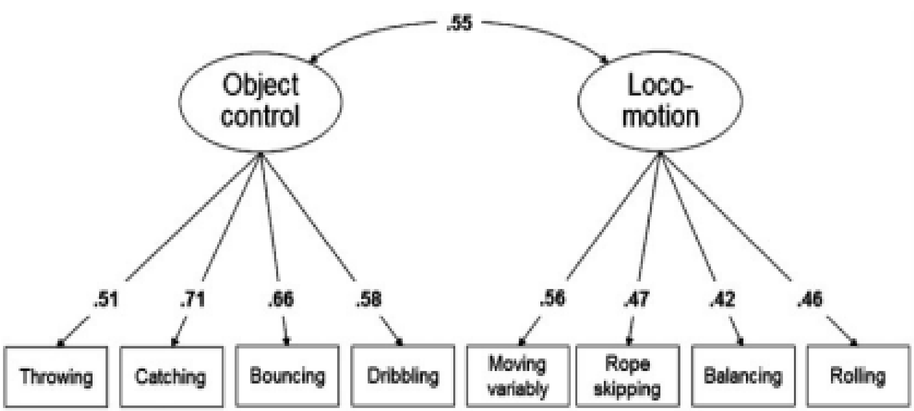

Figure 5. Mutual correlations between disciplines and their entire group and also between groups – Switzerland ("DSBG4public.ch",2016)

Discussion

We can say, that the chosen disciplines are similarly challenging between both countries. According to the measurements, the Swiss students turned out to be better in the area of Object-movement than the students from the Czech Republic. The most difficult discipline for students from both countries was the item Throw on the target. The students from Switzerland achieved significantly greater results in the discipline "Bouncing." In most cases, students from the Czech Republic finished with better results from area Self-movement items.

On the basis of these psychometric results, the MOBAK-3 test battery can be accepted as suitable for the evaluation of the effects that P.E. has on basic motor competencies.

Conclusion

In both states the results have been similar in most items. Students in both countries achieved bad results in items „Throwing at the target" and „Rope skipping". We recommend simplifying these disciplines. Students from both states finished with results that were significantly above the average. It was at the discipline „Moving variably". The items from the area Object-movement are for third-grade students more difficult, and they finish with worse results. The area Self-movement are easier and students are more successful. Altogether, we can say that the test battery MOBAK 3 is useful in both areas. We think that it would be great to discuss certain adjustments of some tests.

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SPORT MEDICINE

HEALTH BENEFITS OF RESISTANCE TRAINING IN CHILDREN

Ignjatovic Aleksandar
Faculty of Education, University of Kragujevac, Serbia

Abstract

Almost one decade ago European Union (EU Guidelines on Physical Activity, 2008), highlight that the decline in physical activity identified problem of sedentary behavior and physical epidemic in youth in Europe like in the rest of the developed world. EU official bodies recognized enormous treat with their guidelines and position statement (EC Expert Group, 2015) but situation is getting worse every year! Constant rate of physical inactivity inevitably leads to increase of several physical, metabolic and mental disorders in childhood or letter in life. Recognition is there but problem remained unsolved, even worse its keep escalating. With latest obesity trends (Lancet, 2017) the importance of increased physical activity level is becoming top priority.

One of the most effective strategy for P.A. level increase is participation of youth in organized resistance training program. This idea has not always been encouraged, but the positive results of the numerous studies in scientific literature over the past decade have clearly stated the benefits. Also, position stands of leading world fitness organizations (American Academy of Pediatrics 2001; American College of Sports Medicine 2006; British Association of Sport and Exercise Science 2004; Canadian Society for Exercise Physiology) all state that resistance training can be very beneficial for children and adolescents.

Although there is not a single chronological age at which it is deemed acceptable for youth to formally start training, recent guidelines recommended that any child engaging in a form of resistance training is emotionally mature enough to accept and follow directions and possesses competent levels of balance and postural control (approximately 6-7 years of age). Additionally, some kinds of resistance training activities should be engaged even from early childhood.

Muscle strength is considered as a powerful marker of health in children and adolescents. For long term physical development of children it's recommended that neuromuscular training that enhances both muscular strength and motor skill should be prioritized. In addition to enhancing muscular strength, power and local muscular endurance, regular participation in a youth resistance training program has the potential to influence several other aspects of health. It may result in improvement of body composition, increased bone mineral density, increased cardio-respiratory fitness, enhanced mental health and well-being and a more positive attitude towards lifetime physical activity.

***Key words**: Resistance training, youth, inactivity, obesity*

Reduced level of physical activity emerged several problems

Current status of society characterizes technological development and overall decrease of physical activity level. Physical activity levels are declining in all parts of the word. Wealthy, middle or low-income countries share a decline in physical activity (*World Health Organization, 2009, Global health risks)*. And it is clear that this decline in physical activity is a key contributor to the global obesity epidemic, and in turn, to rising rates of chronic disease everywhere (WHO, 2009, 2010). Childhood obesity is at constant rate of increase. Today there are 10 times more obese children than four decades ago (Lancet, 2017). Physical inactivity is considered as a fourth leading risk factor, directly responsible for death of more than 5 million people per year in the world (Lee, 2012). In addition, a direct cost of physical inactivity is estimated to more than 80 billion euros per year in Europe with expectation for future increase by 2030. Studies in Europe and the United States find that a moderate-to-vigorous physical activity among children during the elementary school age is significantly decreasing (Riddoch, 2004; Nader, 2008). In Europe there is a cut in half from 9-year-olds to 15-year-old children (48% for boys & 54 % for girls), and in the US for the same age period physical activity drop is by 75%.

The latest estimations (Lee, 2017) from US suggest that only 32% of 8-11 year old children have sufficient physical activity (exercise for 25 minutes a day/three days a week by guideline developed by the Sports and Fitness Industry Association). Maintaining current level of physical activity would result in 8.1 million of these children being overweight or obese by 2020 in the US. Significant amount ($21.9 billion) in additional medical costs and lost wages could be avoided if only half of the children obtain sufficient physical activity level (Lee, 2017). Most diseases become clinically manifested mainly during adulthood, but the actual problem begins in childhood when lifestyle habits such as physical activity are established (Summary report *Pediatrics*, 2011). Increase in the level of physical activity by encouraging activity and involvement in everyday physical activity can be one of the most effective ways for the magnitude decline and for overcoming this problem.

Almost one decade ago European Union (EU) Guidelines on Physical Activity (2008), highlight that the decline in physical activity identified problem of sedentary behaviour and physical epidemic in youth in Europe like in the rest of the developed world. EU official bodies recognized enormous treat with their guidelines and position statement (Guidelines on Physical Activity, 2008, EU 2015) but situation is getting worse every year! Constant rate of physical inactivity inevitably leads to increase of several physical, metabolic and mental disorders in childhood or letter in life. Recognition is there but problem remained unsolved, even worse its keep escalating. With latest obesity trends (Lancet, 2017) the importance of physical education is becoming top priority.

Muscular strength decrease in children

Important aspect of physical fitness and health status is muscular strength. In an extensive prospective study of male adolescents low levels of muscular strength were recognized as an important risk factor for major causes of death including cardiovascular disease in an extensive prospective study of male adolescents aged 16–19 (Ortega et al., 2012). Additionally, decrease of muscle strength may cause significant functional limitations (Takken, 2003).

Loss of skeletal muscle mass occurs naturally with aging but also, during disease and physical inactivity. This physical inactivity is recently, more related to current life style in children. IT can be both a cause and consequence of inactivity. As a result of skeletal muscle loss, the reduction in total energy expenditure in adults decreases by about 30% (Chau et al., 2008), and similar decrease could be expected in youth. Usually, this lose may contribute to weight gain leading to obesity. On the other hand Physical inactivity can be an effect of obesity, in the sense that the inflammatory state and metabolic disruption that accompany obesity set the stage for chronic fatigue and muscle weakness. Additionally, there are numerous psychological factors explaining why obese children are not so fund of different kind of physical activities.

Unfortunately, recent epidemiological research and studies (Tudor-Locke, 2010; Runhaar J, et al., 2010, Ignjatovic et al. 2017) suggests that contemporary children and adolescents are not as active as they should be. There are evidence based research pointing a reduction over the years in children's participation in physical activity and organized community sport (Dollman, Norton, & Norton, 2005; Donnelly & Lambourne, 2011). Even more alarming, reductions in physical activity start in early preadolescence. If we compared present day physical capabilities with the ones 10 years ago, we would come to a similar conclusion. There are several studies investigating different population, but coming to the same conclusion. There is an evident trend of decrease in children and adolescents muscular capabilities observed in English, Dutch, Spanish and Serbian primary school children and adolescents (Cohen, 2011; Moliner-Urdiales 2010, Ignjatovic, 2017). Without interventions that target deficits in muscular fitness and motor skill performance early in childhood, these contemporary trends are likely to continue and the gap between youth with low and high levels of muscular fitness and motor skill competence will continue to increase parallel with their growth.

Resistance Exercises for children

There is a variety of different kinds of resistance training programs that are very popular among males and females of different age categories. Resistance training with free weight and machines could be considered classical and most often used in research. Recently, other forms of resistance training are coming in the focus of interest of research as well as a chance for use in physical education classes, and other forms of organized physical activities for children (Ignjatovic, 2017). Resistance training with medicine ball is an old form of training that has new life in the last decade and is one of the forms of resistance training and testing most frequently used with young subjects (Davis et al., 2008; Ignjatovic et al., 2012). Plyometric training has also been frequently used in research involving youth in the last decade. After the early statement that plyometric training is not suitable for kids, several position stands and review articles (National Strength and Conditioning Association, 2009) encourage researchers to proceed. However, many forms of training that are widely used in adult athletes as well as with sedentary subjects and seniors are not investigated in children and adolescents. There are several studies that involved different forms of resistance training: exercises on unstable surface (Bratic, Radovanovic, Ignjatovic, Bojic, & Stojiljkovic, 2012; Radovanovic, Bratic, Marinkovic & Ignjatovic, 2013), exercises with pilates ball (Ignjatovic et al., 2008), and exercises with punching bags (Ignjatovic et al., 2007).

Whether or not children and adolescents should participate in resistance training programs has been a highly debated topic among experts in the field of exercise and health for the past few decades. Participation of youth in organized resistance training programs has not always been encouraged, but the positive results of the numerous studies in scientific literature over the past decade have clearly stated the benefits. Also, position stands of leading world fitness organizations (American Academy of Pediatrics 2001; American College of Sports Medicine 2006; British Association of Sport and Exercise Science 2004; Canadian Society for Exercise Physiology 2008; National Strength and Conditioning Association, 2009) all state that strength training can be very beneficial for children and adolescents.

Health benefits of resistance training in children

Several experts have suggested that resistance training may offer observable health value to obese children and adolescents (Faigenbaum & Westcott, 2007. Benson et al., 2008a). Similarly, several researchers have published results of programs that target increasing physical activity as a method for reducing obesity in children (Shabi, 2006; Benson, et al, 2008b). Apart from effectiveness of some forms of resistance training programs on obese children and adolescents, this form of training allows participants not to feel inferior and bad as most usually happens with some other forms of physical activity that involves continues effort that they are unable to stand. Willing and joyful participation of obese children and adolescents in different forms of resistance training programs can be explained by the fact that resistance training is typically characterized by short periods of physical activity interspersed with brief rest periods between sets and exercises, which is more consistent with how youth move and play, and above all, allows overweight persons to fully participate without forcing them to give up as in majority of other physical activity exercises and physical activity games.

In addition to enhancing muscular strength, power and local muscular endurance, regular participation in a properly design and supervised resistance training program has the potential to influence several other aspects of health and fitness. Regular participation in resistance training may result in improvement of body composition, increased bone mineral density, increased cardio-respiratory fitness, enhanced mental health and well-being and a more positive attitude towards lifetime physical activity. Almost every position stand from leading health and fitness organization (American Academy of Pediatrics 2001; American College of Sports Medicine 2006; British Association of Sport and Exercise Science 2004; Canadian Society for Exercise Physiology 2008; National Strength and Conditioning Association, 2009) state that there are psychological and sociological benefits in youth as a result of different kinds of resistance training usually without concrete research supporting this statement.

The research is convincing that resistance training can favorably affect cognitive function in adults. Different studies examining the effects of mental health in adults have focused on: effects on anxiety (O'Connor, Herring, & Carvalho, 2010), improved brain cognition (Anderson-Hanley, Nimon and Westen, 2010), effects of depression, chronic fatigue, on self-esteem, quality of sleep and overall mental health (O'Connor el al., 2010). The evidence supporting resistance training for the improvement of several major mental health issues is quite strong and impressive. The physiology behind it is likely to be multi-factorial adaptations (van Praag, 2009). It involves new nerve cell generation in the brain, increase in neurotransmitters function and new brain blood vessels for more efficient oxygen delivery and waste product removal.

However, there is no clear evidence for such statements in youth. Children and adolescents are not just miniature adults dressed in children's clothes, but individuals with bodies and minds that grow and develop rapidly mentally, physically, and emotionally. During this period of intensive growth all influences, positive and negative could have a great impact on young individuals. It is a priority to have strong evidence of influence of different resistance training programs on children and adolescents.

Today, medical and health organizations agree that there is a necessity for a vigorous daily physical activity. Majority public health recommendations indicate that children and adolescents should accumulate at least 60 min of moderate to vigorous physical activity (MVPA) each day (WHO, 2010). Most frequent chronic diseases today could be prevented or postponed by adoption of healthy habits in childhood, and one of the potential exercise modality could be composed of resistance exercises.

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TYPES OF INJURIES OCCURRING WHILE USING RESTRAINT DEVICES IN POLICE WORK

Bugala Martin
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

From the kinanthropological point of view, restraint devices represent an application level of combatives. It is a utilitarian use of combatives for the purpose of professional self-defence, the primary aim of which is to protect lives and health of citizens through developing physical abilities and skills, tactical thinking, psychical resistance etc. Restraint devices are used in case of physical conflict between the Police and a citizen according to paragraph Sec. 52 of Act no. 273/2008 Coll. on the Police of the Czech Republic, Sec. 45 of Act No. 300/2013 Coll., on the Military Police of the Czech Republic and Sec. 18 of Act No. 553/199 Coll. on Municipal police of the Czech Republic. They can also be used when a citizen refuses to cooperate with the Police. In this study, we have focused on mapping particular types of injuries occurring while using restraint devices. This research is based on a pilot study entitled *Identity of Police Organizations: Resolving Conflict Situations*, which was mapping types of injuries with the Municipal Police. The research methodology is the same, but this time we have focused on all kinds of police forces in the Czech Republic (the Police of the Czech Republic, the Municipal Police and the Military Police).

Aim: The aim of the study is to find various types of injuries occurring while resolving physical conflicts by using restraint devices.

Methods: The work is conceived as descriptive and qualitative - quantitative. For data collection we used the *Questionnaire Solution of Conflict Situations and Circumstances of Assaults (SoCon)*. For data analysis we used the qualitative analysis with a three-stage coding. The coding was inductive, which means there had been no categories created before the research but all of them emerged during the data analysis. The quantitative data were analyzed on the basis of the descriptive statistics and frequency is expressed in percentage. The research samples were the Police of the Czech Republic, the Municipal Police and the Military Police. The total number of respondents was 908.

Results: 14 % of those surveyed have never faced the attack on policeman. The rest of the respondents meet physical aggression from 46 % yearly through 29 % monthly, 5 % weekly and 3 % daily. 2 % of respondents did not respond. The most common occurrence of injuries in security forces are:

- Scratches and abrasions (facial part)

- bruises (ears, cervical and lumbar spine, back, ribs, arms - elbows, hands and fingers, legs - ankles, big toes)

- Luxation (shoulders, fingers, ankles)

- Fractures (nose, nasal bulkhead, ribs, the fifth vertebra, hands - wrist, fingers)

- Lacerations (hands, facial part).

- Teeth knocked out

- Concussion

*Conclusion***:** The acquired knowledge helps to map vulnerable zones of the human body. It points out the need of dealing with the safety of policemen, protective devices and equipment. These results can enrich the professional training for the service interventions and the use of restraint devices in police work. The information obtained is important and can be included in the basic education of the security services as well as in further police training.

Key words: *Security forces, police, physical attack, violence on police, physical aggression, injuries, restraint devices, conflict situation, handling physical attack, solutions*

Introduction

Police forces which act as law enforcement officials often encounter conflicts with citizens who do not respect the rule of law and violate the law. This confrontation may in some cases lead to physical conflicts and a higher risk of injury because of erratic work hours, insufficient sleep and training (Violanti et al., 2012). In accordance with Sec. 52 of Act no. 273/2008 Coll. on the Police of the Czech Republic, Sec. 45 of Act No. 300/2013 Coll., on the Military Police of the Czech Republic and Sec. 18 of Act No. 553/199 Coll. on Municipal Police of the Czech Republic, the police may apply restraint devices when required by given situations. The use of restraint devices may, however, lead to injury of on-duty police officers due to the level of violence present and inadequate training of the police (Brandl & Stroshine, 2012). These findings point to the demanding nature of the police profession. The dangers they face bring about stress that limits their behaviour in risky situations (Anshel, 2000).

It is essential to provide efficient education in police training and find possible means of reducing injuries in police performance. Further necessary knowledge includes an overview of opportunities and threats for police organizations. As a result, the police can better respond to the cultural changes that may occur and affect the work of the police (van den Born et al., 2013). Knowledge of police culture is therefore a specific indicator for planning and implementation of (inter) national and inter-organizational collaborations as well as organizational change (Saskia Bayerl et al., 2014). During a physical confrontation between a policeman and a citizen, we consider self-defence and practical knowledge of limiting devices as essential. For this reason, self-defence is perceived as a key competence in police training (Reguli, Bugala, & Vít, 2015).

From the kinanthropological point of view, restraint devices represent an application level of combatives. It is a utilitarian use of combatives for the purpose of professional self-defence, the primary aim of which is to protect lives and health of citizens through developing physical abilities and skills, tactical thinking, psychical resistance etc. (Vít, 2016).

Methods

The work is conceived as descriptive and qualitative - quantitative. For data collection we used the *Questionnaire Solution of Conflict Situations and Circumstances of Assaults (SoCon)*. The first part identifies types of conflicts between citizens and police officers and the ways to solve them. The second part deals with the detection of abilities of police officers to work with the principles of community policing.

In the quantitative part the data were generated into the Microsoft Office Excel spreadsheet. Afterwards the data were transferred into the STATISTICA software where they were analyzed. Then, as the very first step we used descriptive statistics in order to detect extreme values and describe the research sample.

In the qualitative part the data were initially generated in the Microsoft Word text process. After that they were transferred to ATLAS.ti software. In this software the data were analyzed and the encoding results were transferred into the network chart. For data analysis we used the qualitative analysis with a three-stage coding (Corbin & Strauss, 2008). The coding was inductive, which means there had been no categories created before the research but all of them emerged during the data analysis. The quantitative data were analyzed on the basis of the descriptive statistics and frequency is expressed in percentage. All statistical operations were performed in the STATISTICA software.

Research sample: The research sample was 908 respondents it total and it is to be found further specified in Table 1. The average age was 35 years, the average time spent working for the police was 9 years and 8 years for the special unit workers. The ratio between genders was 77:23, as you can see in Table 2. We focused on all types of security forces in the Czech Republic. The first group was the Police of the Czech Republic where we obtained data from 524 respondents. The second group was the Municipal Police. In this case we received data from 309 respondents. The third and last group was formed by the Military Police and there, as you can see in Table 3, we received 75 respondents. It can seem to be only a small group but the Military Police is a much closed organization, and therefore it is difficult to conduct inquiries. Our research sample covered all types of security forces in the Czech Republic.

Table 1. Basic characteristics of the research sample

	Study sample N	Average	Median	Minimum	Maximum	Standard deviation
Age	908	35.377	34.000	21.000	60.000	8.252
Time spent working for the Police	908	9.432	8.000	0.000	33.000	6.080
Service Time in the Special Police Unit	908	8.442	6.000	0.000	38.000	6.220

Table 2. Gender ratio

Gender	Frequency	Cumulative frequency	Percentage	Cumulative frequency in percentage value
Male	695	695	76.542	76.542
Female	213	908	23.458	100.000
MD	0	90	0.000	100.000

Table 3. Ratio of Security Forces of the research sample

Frequency of security forces	Frequency	Cumulative frequency	Percentage	Cumulative frequency in percentage value
Police of the Czech republic	524	524	57.709	57.709
Municipal police	309	833	34.031	91.740
Military police	75	908	8.260	100.000
MD	0	908	0.000	100.000

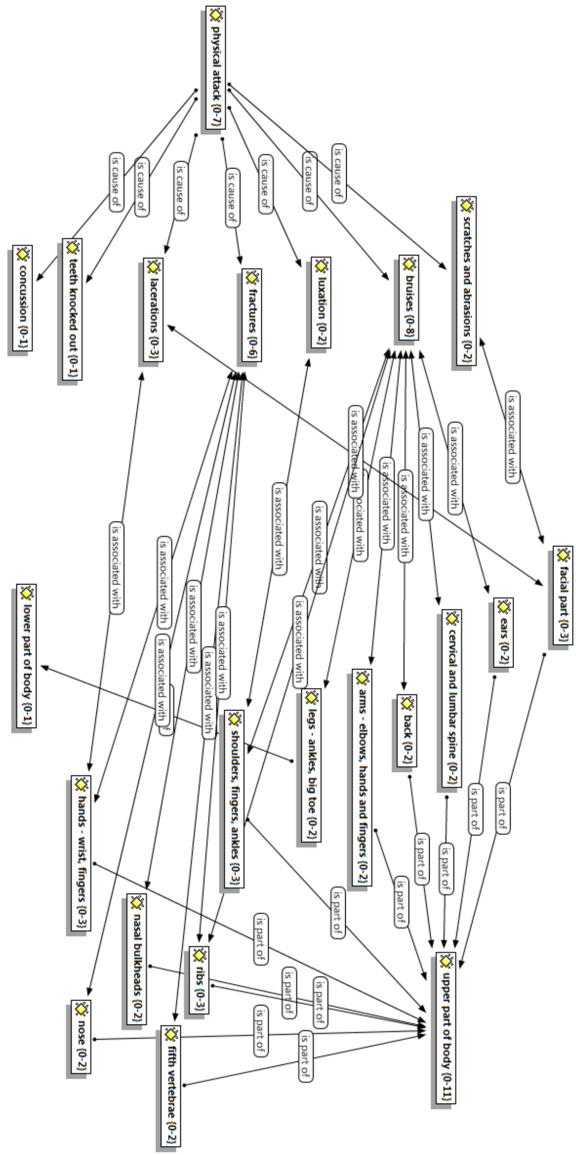
Results

The cases of aggression of citizens against police officers are presented in Table 4. The frequency of physical attacks on police officers is as follows: 14 % of the policemen surveyed have never faced the attack. The rest of the respondents met physical aggression from 46 % yearly through 29 % monthly, 5 % weekly and 3 % daily. 2 % of respondents did not respond. These results confirm that police officers do face physical aggression which may lead to injuries. The injuries may result from a physical confrontation with an attacker but they can also come due to an inadequate training in the use of restraint devices. On a network chart in Figure 1, we can see different types of injuries occurring during physical conflicts between police officers and citizens. According to these results, the physical aggression of citizens brings about injuries that predominantly fall upon the upper half of the body. The most common occurrence of injuries in security forces are: **scratches and abrasions** (facial part), **bruises** (ears, cervical and lumbar spine, back, ribs, arms, elbows, hands and fingers, legs – ankles, big toes), **luxation** (shoulders, fingers, ankles), **fractures** (nose, nasal bulkhead, ribs, the fifth vertebra, hands - wrist, fingers), **lacerations** (hands, facial part), **teeth knocked out**, **concussion.**

Table 4. The frequency of physical aggression directed at police officers

Categories	Frequency	Cumulative frequency	Percentage	Cumulative frequency in percentage value
Never	127	127	13.987	13.987
Per annun	423	550	46.586	60.573
Monthly	264	814	29.075	89.648
Weekly	48	862	5.286	94.934
Daily	30	892	3.304	98.238
MD	16	908	1.762	100.000

Figure 1. Network chart of injuries



Conclusion

The findings lead us to conclude that the incidence of injuries in resolving conflict situations involving violence is not negligible. Police officers have to face physical aggression which can bring about injuries and the subsequent limitation of police officers' availability for the service. This information may be used in the creation of defence strategies and also in order to improve training of policemen in the application of restraint devices. Furthermore, considering the research results we can define attack zones mostly hit by the attacker against the police officer. This knowledge can enhance the efficiency of the in-service police training and may subsequently reduce the risk related to the resolution of conflict situations involving violence as well as decrease the injury rate among police personnel.

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POSTURE ANALYSIS OF FEMALE STUDENTS OF THE SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

Cepková Alena[1], Šooš Lubomír[2], Zemková Erika[3], Uvaček Marián[4]
[1,2,4] Faculty of Mechanical Engineering of the Slovak University of Technology in Bratislava
[3] Faculty of Physical Education and Sports of the Comenius University in Bratislava

Abstract

The paper aims to evaluate body postures of female students of the Slovak University of Technology in Bratislava (STU).

Method: The somatoscopic method of the posture evaluation according to Klein and Thomas, as modified by Mayer (1978), was applied. In particular, the methodology focuses on somatotype identification. Consequently, the 5 basic human body parts were evaluated. Head posture, chest shape, abdomen shape, head declination, pelvic inclination, spine curvature, shoulder height and shoulder blade posture. Each of the measurements applies a 4-grade scale. The total score shows the evaluation of the human body posture. Female students (n=32) at the age of 22±0.5 on average took part in the measurements.

Result: According to the test, tested subject achieved good, almost excellent body posture- that means 8.094 points on average. A minimum value was 5 points, which refers to an excellent posture and a maximum value was 11 points indicating fatigue posture. The best results were achieved by the students in their head posture 82% (1.188 points on average), 18% of the female students achieved 2nd degree of evaluation. Unfavourable state was found in abdomen shape and pelvic inclination too, and only 53% of the female students achieved the correct state. 62% of the female students had obvious or slightly flattened spine curvature. The worst results were found in the shoulder and shoulder blade postures (2.344 points on average). Only 16% of the female students were included in the scale of 1.37% and the scale 2 and even 47% in the scale 3.

Conclusion: All students (100%) represented a mesomorph body type. Shortened and weakened muscles of the female students were evaluated according to Janda (1982) for our purposes, modified by Thurzova (1992) for the purposes of the physical education practice. They correspond closely with the body posture. 18% of the female students had the shortened pectoralis major muscle, 26% of them trapezius muscle, pars superior and 24% of them had shortened tensor fasciae late muscle. The most weakened muscles were the lower shoulder blade fixators up to 33% of the female students and abdominal muscles on the second position represented by 29% of the

students. The questionnaires showed that 63% of the female students have never felt spine pain and 21% of them have experienced lumbar spine pain.

Key words: *posture, Klein and Thomas test modified by Mayer, spine pain, postural muscles*

Introduction

Nowadays period of technical progress brings a negative increasing tendency of human being's sedentary life style. Lack of activity may affect a human body anatomical structure, its particular parts, proportionality, spine, joints, muscles and their relationships, connections, mobility and functionality, what can result in a defective posture of an individual. Neurophysiological and neuroregulation mechanisms, providing postural reflex formation and postural movement stereotype, may start modifying markedly (Hrčka, 2009). In these days, the number of children with wrong posture is increasing. Proportion of children with defective posture represented 20% of overall school population in the 90s of the last century. Today the number exceeds one third and has permanently increasing tendency. Body posture became a negative syndrome, respectively civilization disease of this period. Filipova states that defective body posture covers one half of primary school pupils today (Filipova, 2000). It should be taken into consideration that unless the defective posture of children is early eliminated, it will result in an increased measure with the adults. Up to 80% of inhabitants in the age of 25-60 have experienced spine pain, however, some studies indicate, that even adolescents have certain problems too (Yhu, 2007). Lumbar and cervical spine pains are the most frequent. The reason is a wrong manner of walking and sitting (wrong body posture, faulty position at the table at home or at work) and improper way of carrying of load (bags) or unsuitable way of stable permanent activity (hoeing in the garden, monotonous posture in a tense position etc.). Chronic pain as a result of long-term, untreated back disorders known as a lower back pain affects significantly the life quality, mobility, increases the risk of cardiovascular diseases. Therefore, according to Roche et al. (2007), as he states in his long-lasting study, less expensive individual, long-term, therapeutic activities within prevention are more effective than expensive treatment programs of spine pain cure. Posture is not important only from the health but also from social points of view. Monitoring of the university students' posture is needed as results from various research areas and analysis and it should focus on prevention of the spine pain beginning caused by defective body posture, through physical activities on the lessons of physical education. There are several authors who dealt with the problems of functional mobility diseases of school population in our country and in the Czech

Republic (Vařekova 1999, Lewit 1996, Kopřivová, Beránková, 2002, Bursová 2005, Kanásová 2011, 2016, Medeková, 2005, Bartík 2006, 2007, Majerník J., Dziaková M., 2012 etc.). Only little knowledge of the posture and functional diseases evaluation of adults is available.

The experiment aimed to find complex posture evaluation of the female students of the Faculty of Mechanical Engineering of the Slovak University of Technology in Bratislava. We supposed the students would have fatigue or even defective body posture with a potential spine pain predisposition.

Methodology and the sample group characteristics

In the introduction, the girls filled out a very short informative questionnaire about their personal spine pain experience. It consisted of five closed questions with the yes/no answer options and it was anonymous (Chart 5). We have used the Klein and Thomas' somatoscopic method modified by Mayer (1978), (Hrčka et al., 2011), to evaluate the students' body posture of the Slovak University of Technology (STU) in Bratislava. This is a method by which five parts of human body are evaluated on the base of visual observation and with the use of the scale from 1 to 4 points. After summary calculation a state of body posture will be evaluated. 1 – refers to an excellent, respectively perfect body posture with the scale from 1 to 5 points. 2 – refers to a good body posture with the scale from 6 to 10 points. 3 – refers to a fatigue body posture with the scale from 11 to 15 points and 4 – refers to defective body posture with the scale from 16 to 20 points (Chart 1). For testing, a square net with the dimensions of 150 cm by 150 cm was used for testing. A point value created according to the Klein, Tomas and Mayer' methodology was allocated with reference to the description of each of the evaluated human body parts of a proband standing in front of the square net (Chart 1). Body posture (BP), chest shape (ChS), abdomen shape (AbS), spine curvature (SpC), shoulder height and shoulder blade posture (ShBP). Testing was carried out by two pedagogues according to the Labudova's description of correct body posture (1992), (Hrčka, 2009). The body posture classification is completed with a classification according to a somatotype divided into mesomorph, ectomorph and endomorph body types. Four types of body posture are indicated in the division separately for males and females. A figure manual was created by the authors for an easier application (Fig. 1). Figure 1 is described in the Chart 1. A refers to the point 1 evaluation, B refers to the point 2 evaluation, C to the point 3 evaluation and D to the point 4 evaluation. 32 females, female students of the 1st and 2nd years of the bachelor study, in the age of 22±0,5 on average were involved in testing, who attended obligatory and elective lessons of physical education once a week. The female students did various types of the aerobic exercise on the lessons. The probands were evaluated at the beginning of the semester on the lessons of physical education. All of them have been informed about the testing procedure and they agreed with its conditions. Afterwards, postural muscles were evaluated according to Janda (1982) and modified by Turzova (1992) for the physical education practice; 4 tests for shortened and 3 tests for weakened muscle evaluation were chosen (Table 3, 4).

Shortened muscles
m. quadratus lumborum
m. tensor fasciae late
m. pectoralis major
m. trapezius, pars superior

Weakened muscles
Deep neck flexors
Abdominal muscles
Lower shoulder blade fixators

Figure 1. The assessment of body posture according to Klein, Thomas and Mayer (Haladová, Nechvátalová, 1997) and percentual distribution of students in respective measurement tests

	Body posture	**Chest shape**	**Abdominal shape, pelvic tilt**	**Spinal curvature**	**The height of shoulders and shoulder blade position**	**Total**
Assessment of body posture (BP)	1. head upright, the angle between the chin and neck is 90°	1. chest is upright and well profiled, sternum is the most protruded area	1. abdomen is retracted and flat	1. curvature is within the physiological limits	1.shoulders are symmetrical and in the same height, shoulder blades are not protruded and have the same height	1. perfect BP upto 5 points
	82%	91%	53%	22%	16%	% students
	2. head slightly protruded forward	2. chest is slightly flat	2. retracted only partially	2. significantly or slightly flat	2. shoulders are not exactly symmetrical, shoulder blades slightly protruded, in the same height	2. good, almost perfect BP 6-10 points
	18%	9%	38%	62%	37%	% students
	3. head protruded forward	3. flat chest	3. frail abdomen	3. higher or flatter curvature	3. uneven height of shoulders, shoulder blades significantly protruded	3.poor BP 11-15b points
	0%	0%	9%	16%	47%	% students
	4. head significantly protruded forwards	4. retracted chest	4. abdomen forms the most protruded area	4. curvature is sifnificantly increased	4. shoulder assymetry, shoulder blades significantly protruded	4. bad BP 16-20 points
	0%	0%	0%	0%	0%	% students

Results

Based on the results of the questionnaire it was found out that 63% of students have never experienced the pain of spinal cord which corresponds to the total value of body holding in test KT students as good, almost perfect test and 21% of them have already experienced pain in the lumbar (waist) area of spine. Also, 9% of students have already felt the pain in the thoraric spine and 7% of students in the cervical spine. However, none of the students has been treated at the doctor for their spinal problems (Figure 5). This implies that the pain of the students in our tests results from the faulty body posture which was proven in our measurements. It was discovered that all tested students (100%) fell into the category of ´mesomorph´ (Figure 1). Subsequently, they were tested in different parts of their body. As for the body posture, students had very good results in their head posture (82%). On average, they gained 1,188 points. This means that their head is upright and the angle between the chin and their neck is 90 degrees. Only 18% of tested students reached lower values, however, only slightly, because their head was somewhat protruded and their chin raised upwards. The shape of the chest did not show any significant deviations from the standard. Female students achieved in average 1,156 points, which means that most students have a well profiled, upright chest and sternum is the most protruded area (91%). Only 9% tested students had worse values, the chest was slightly flat. As for the abdomen shape, the average values were worse than those in former measurements. The average value was 1,531 points. 38% of students had a partially retracted abdomen and 9% of them had a weakened (flabby) abdomen. Measurements of students also showed worse values in the curvature of spine than in the shape of their abdomen. The average value was 1,875 points. 62% of students had either significantly or slightly flat spine and 6% of tested students proved to have even more significant curvature or flatness of spine. The worst values were noted in the measurements of the shoulder height and the shoulder blade curvature. The average value was 2,344 points. 37% of students had asymmetrical shoulders and their shoulder blades were slightly protruded- although at the same height. 47% of students did not have the same height of shoulders and their shoulder blades were significantly protruded. The overall body posture of students may be evaluated as good- almost perfect. The average measured value of 8,094 points represents the sum of points in the five tested areas of the body. Only one student from the whole sample had a perfect body posture (5 points), three had an incorrect body posture (up to 15 points). The remaining students fell into the category of almost perfect body posture (from 6 to 10 points). Mikuľáková et al. (2012) employed a methodology of body posture assessment based on Klein, Thomas and Mayer when evaluating the quality of body posture system of dentists and university students. The average value of examined body posture in the ´industry´ group was 11,44 points (min.7, max.18), whereas in the group of students it was 11,58 points (min.7, max.20). In both groups individuals with faulty body posture were identified and diagnosed with serious changes in their posture system. The methodology of Klein, Thomas and Mayer was employed also by Kanásová (2005) when assessing 15-18 year sportsmen and Kanásova (2011) when assessing 11-15 year boys. She discovered a high occurrence of faulty body posture in tested sportsmen, with a wide range of different subclasses of body posture with respect to the specific sports fields. Most authors, for example, Medeková et al. (1993, 2009), Medekova -Kyselovičová (2012), Bekö (2008), Ruivo, R. et al. (2016) focus on assessment of body posture in groups of elementary schools, which makes the comparison of results more complicated. The defects in body postures were also assessed according to the evaluation of shortened (contracted) muscles by Janda (1982). 16,70% students had a shortened quadratus lumborum muscle, 24,00% of students had shortened tensor fasciae latae muscles of the spine, while 18,00% students had a shortened pectoralis major and 25% of the superior trapezius muscle. 33% of students had weakened lower fixators of shoulder blades, 29% suffered from abdominal muscle fatigue and 17% from deep neck flexors fatigue (Figure 4, 5).

Figure 2. Statistical evaluation of tested women using the methodology of Klein and Thomas, as modified by Mayer

Name	**BP**	**ChS**	**AbS**	**SpC**	**ShBP**	**Total**
The mean value (arit. average)	1,188	1,156	1,531	1,875	2,344	8,094
Standard deviation	0,397	0,448	0,621	0,609	0,701	1,711
Median	1,0	1,0	1,0	2,0	2,0	8,0
Min.	1	1	1	1	1	5
Max.	2	3	3	3	3	11
Variance	1	2	2	2	2	6

BP- body posture, ChS – chest shape, AbS – abdominal shape, SpC – spinal curvature, ShBP – the height of shoulders and shoulder blades

Figure 3. Percentual distribution of types of muscle shortening among students

Muscle Shortening	Quadratus lumborum muscle	Tensor fasciae latae muscle	Pectoralis major	Superior trapezius muscle
	16,70%	24,00%	18,00%	25%

Figure 4. Percentual distribution of types of muscle fatigue among students

Muscle fatigue	Deep neck flexors	Abdominal muscles	Lower fixators of shoulder blades
	16,70%	29,00%	33,00%

Figure 5. The questionnaire on the sensation of pain in the spinal cord

Question	yes
I have never experienced any pain in the spinal cord	63%
I have already experienced pain in the cervical spine	21%
I have already experienced pain in the thoracic spine.	9%
I have experienced pain in the cervical spine.	7%
I have been treated by the doctor on the pain of spinal cord.	0%
	100%

Conclusion

The choice of methodology employed in our body posture assessment test (Klein, Thomas, as modified by Mayer: 1978) was motivated by its several advantages in terms of its short duration, low need for material equipment and high credibility. To ensure that no significant deviations in measurements would arise, it was crucial for the test to be conducted by the same examiners. The test of postural muscles by Janda (1982) was also included. Based on our measurements, students with predisposition to pain in the spinal area had the deviations in the body posture. These findings correspond to results of (Thurzová, 2001; Kováčová, 2003; Kanásová, 2004, Šimončičová, L.– Kanásová, J. 2015) who have reported 100% occurrence of muscular disproportion in their groups and a higher percentage of weakened than shortened muscles in their sample of female students.

The regular physical activity of our tested group was limited to the number of PT lessons that our female students took as part of their compulsory-elective curriculum at university, which corresponded to one session in a week and a walking activity to and from school. This type of physical activity is, in our point of view, insufficient. Significant deficiencies of our students are mainly in the shoulder and shoulder blade height, weakened (flabby) abdomen and the spinal shape. These deviations from the norm of the standard body posture result from the long-term sedentary activities, faulty body posture formed by sitting at the computer screen and during lectures, as well as by the wrong carrying of handbags. Struhára et.all (2012) describe in their works upper cross syndrome. Upper Cross Syndrome (UCS) includes forward head posture, increased cervical lordosis and thoracic kyphosis and protracted shoulders. We wanted to show that there are so many ways how to figure this out. We agree with Kolář (2007) that letting the body posture develop ´naturally´ throughout the years is very irresponsible in a civilized society. Several research studies have shown that sport activities have a positive impact on the looks, shape, decreased body fat and risk of muscular injuries, reduced spinal cord pain, faster recovery after psychologically demanding work, higher work efficiency and increased capability to manage stress situations. Cook, G.,(2003), Allen, B. A. et. al. (2013), Han, J. et al. (2016), Vasiľovský, et.al. (2016) and others focus in their research especially on the prevention of occurrence of muscular disproportions in relation to preventing health disorders and injuries, but also on the methods of elimination of functional disorders. Our main goals lie in making the content of PT lessons more appealing, while focusing on the health of our students and helping them to adopt healthy, sport-related lifestyle (Sedláček et al., 2008).

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ANTHROPOMETRY, BODY COMPOSITION AND ACE GENOTYPE OF ELITE FEMALE COMPETITIVE SWIMMERS AND SYNCHRONIZED SWIMMERS

Grznár Ľuboš [1], Labudová Jana [1], Rýzková Eva [1], Putala Matúš [1], Slaninová Miroslava [2], Sekulić Damir [3], Polakovičová Mája [1]

[1]Faculty of Physical Education and Sports, Comenius University, Bratislava, Slovak Republic

[2] Faculty of Natural Sciences, Comenius University, Bratislava, Slovak Republic

[3]Faculty of Kinesiology, University of Split, Split Croatia

Abstract

*Purpose***:** This study aimed to evidence characteristics and possible differences in anthropometric – body build indices (ABB), and Angiotens in Converting Enzyme (ACE) genotype among female synchronized swimmers (SYN), competitive sport-swimmers (CSS) and age-matching non-athletic control group (CON).

*Methods***:** The sample comprised 59 females (SYN: N=14; 15±1.5; CSS: N=12; 16.1±0.6; CON: N=33, 16.0±0.6 years of age). The subjects involved in SYN and CSS groups were current members of Slovak National teams. Anthropometrics were measured by standard techniques, while body composition was analyzed by bioelectrical impedance. Genomic DNA was extracted from the buccal swabs, and the Polymerase chain reaction of the polymorphic region of the ACE gene containing either the insertion I or deletion D fragment was performed (ACE I/D). Kolmogorov Smirnov test showed normality of the distributions, and homoscedasticity of the variance was proven by Levene's test for all ABB variables. Therefore, analysis of the variance with consecutive Scheffe's post-hoc was calculated to establish differences among groups in ABB. The ACE I/D variation differences between groups were identified by Chi-Square test. Statistical significance of $p<0.05$ was applied.

*Results***:** The ANOVA identified significant differences among groups for all ABB variables. Specifically, SYN weighted less than other groups, had lower BMI and body-fat-percentage than CON. The CON had lowest percentage of muscle-mass, and had shortest forearm-length. The CSS had longest upper-limb length, and were taller than SYN. The ACE I/D genotype frequencies met Hardy-Weinberg expectations in all three groups. The ACE I/D genotype distribution and allele frequencies did not differ significantly among groups.

*Conclusion***:** Differences in anthropometrics between SYN and CSS are clearly connected to specific sport-tasks and requirements. The sport of synchronized swimming requires low body weight associated with a lower percentage of body fat and longer forearm. Meanwhile, the body height and arm length are essential for sport swimming, as the basic factors determining the competitive performance in this sport. We did not provide evidence for significant differences of variation of the ACE I/D polymorphism between observed groups.

Key words: *synchronized swimming, competitive sport-swimming, anthropometry, body composition, ACE I/D polymorphism.*

Introduction

Competitive swimming and synchronized swimming are Olympic aquatics sports included in International Swimming Federation FINA. Both sports are performed in specific water conditions. The way for achieving success in competitive swimming is different as in synchronized swimming what is caused by varied demands for sports performance. Swimming performance is influenced by a complex interaction of physiological, morphological, neuromuscular, biomechanical and technical factors and the ability of a swimmer to repetitively overcome the resistance of the water in an efficient manner (Maglischo, 2003). Consequently, competitive swimming asks for specific anthropometric characteristics and body built of swimmers (Wakayoshi et al., 1996, Girold et al., 2006). Synchronized swimming requires a combination of endurance (both aerobic and anaerobic), strength, flexibility, acrobatics and swimming abilities that must be performed together as one artistic performance (Mountjoy, 2009, Gabrilo et al., 2011). These performances lasting about 2 to 4 minutes (duration of the routine differs according to age and competitive category), performed at high levels of intensity with long periods spends in apnea (Alentejano et al., 2012; Homma, 1994). In Synchronized swimming there are just a few papers that bring us valuable information about anthropometry, and information on specific body built of synchronized swimmers changed with the improvement of this sport. For example, early studies suggested body fat percentage 20-24 % (Evans et al., 1985, Roby, 1983), while percentage of 15% body fat is suggested in recent investigations (Peric et al., 2014). Some authors (Claessens et al., 1999) suggest that height and weight are strong factors influences on the success, giving clear criteria for the selection of athletes in general. Lundy (2011) highlighted importance of those body criteria which arises for better buoyancy in the water, which does not allow high muscularity or very low levels of body fat. Body morphology, aerobic, anaerobic capacity and the muscle strength are one of the most important factors underlying athletic performance. Every sport has specific requirements that can be considerably different between sports. Besides the training and nutrition the genetic factors influence mostly the variance between individual athletes. Up to now more than 200 genetic variants are associated with physical performance (Eynon et al., 2011). One of the most observed gene polymorphisms associated with sport performance is ACE I/D gene polymorphism. ACE is a crucial part in renin-angiotensin-aldosterone system, which maintains the circulatory homeostasis. In cardiac muscle ACE genotype variants influence the left ventricular mass changes in response to stimulus. The D allele is associated with an increased response to training, whilst the I allele is associated with the lower cardiac growth response. In skeletal muscle, the D allele is associated with greater strength gains in response to training. In general, the frequency of genotypes II and ID is higher in athletes practicing sports requiring a high aerobic activity. On the other hand, a high level of ACE linked to the DD genotype is more frequent in strength and power athletes. (Puthucheary, et. al., 2011). Nazarov et al. found an excess of the D allele in short distance swimmers and of the I allele in middle distance swimmers. Tsianos et al. (Tsianos et al., 2004) compared long open water swimmers competing and found an association of the ACE I allele with elite endurance athletic performance, and the D allele with short-distance swimming. The combined analysis of the two loci has proven the *ACE* I and *ACTN3* X alleles maybe beneficial to swimmers who compete in long distance races (Grenda et al. 2014).

Material and Methods

Subjects

Total of 59 female subjects were divided into three groups: synchronized swimmers (SYN; N=14; 15±1.5 years of age), competitive sport-swimmers (CSS: N=12; 16.1±0.6 years of age) and age-matching non-athletic control group (CON: N=33, 16.0±0.6 years of age). All members of SYN group were member of national Slovakian synchronized swimming team. Additionally, 4 of them participated on European Games, 2 of them participated on European Junior Synchronized Swimming Championship and 6 of them had taken part in FINA World Championships. All participating swimmers were specialized to short distance (50, 100 and 200m) and were finalists of the Slovak National Championships. Three of them were members of national Slovakian swimming team and two of them had taken part in LEN European Championships. All participants were informed about the aim of this research and gave written consent to participate on the study.

Methods of measurement

In our research we measured subjects body composition, mass, height, sitting height, length of whole preferred arm and length of forearm of the same arm.

The body composition on Omron BF511 device (Omron, Japan), a weight scale with bio-impedance body scanner. This device self-calibrate each time during power on for precise weight measurement. It also have two bio-impedance metallic plate platforms. One platform is for placing participant feet and second one is for holding in arms. Before participant stood on the device individual Height was set to the device. Each participant stood upright on the Omron BF511 device and held second bio-impedance device in straight arms in front of body. This device calculate BMI index from measured weight and entered height. Bio-impedance measurement of this device is focusing on body fat percentage and muscle mass percentage.

Measurement of body height

Each participant was measured by standardized method on standardized stadiometer in standing position with feet on the floor board with beck to the vertical backboard of the stadiometer (Anthropometry Procedures Manual, 2007).

Sitting Height

For measuring sitting height, the examiner moves the specially-made measurement box onto the floor board of the stadiometer. Participant sits on the box with his or her back and buttocks to the backboard of the stadiometer. His or her arms and hands were resting at the sides and he knees was directed straight. The measurement then fallows the procedure as in measurement of the body height.

Arm length

The participant stands with the arms hanging loosely by the side of the body, fingers outstretched. A measurement was made from the acromiale (lateral edge of the acromion process, e.g. bony tip of shoulder) to the tip of the little finger. Measurement was made on the preferred side, following the anthropometric standard, though a measurement of either side would be assumed to be the same in most cases.

Forearm length

Arm of the participant was flexed at the elbow to 90 degrees. Measure of the distance from the tip of the elbow to the tip of the middle finger was measured and recorded to the nearest 0,1 cm.

Genetic analysis

Genomic DNA was extracted from buccal swabs using cotton stick and standard protocol with Chelex (Bio-Rad). After extraction, samples were replaced together with cotton stick to NucleoSpin forensic filters (Macherey Nagel) and spined at high speed in microcentrifuge. Genotypes were determined using regular PCR with primers: forward, CTGGAGACCACTCCCATCCTTTCT; reverse, GATGTGGCCATCACATTCGT-CAGA. PCR was performed in thermocycler (Biometra). The thermal-time PCR was as follows: initial denaturation for 8 min at 95 °C, and 30 cycles with denaturation of 1 min at 95 °C, annealing for 45 s at 58 °C and extension for 45 s at 72 °C, and final extension at 72 °C for 10 minutes. Amplification products were visualized using 2 % agarose gels stained with ethidium bromide. The sizes were 490 bp for I allele and 190 bp for D allele.

Statistical analysis

Kolmogorov Smirnov test showed normality of the distributions, and homoscedasticity of the variance was proven by Levene's test for all anthropometric-body built variables (ABB variables). Therefore, analysis of the variance with consecutive Scheffe's post-hoc was calculated to establish differences among groups in ABB. The ACE I/D variation differences between groups were identified by Chi-Square test or Fisher exact test (when an expected cell count was <5). Statistical significance of $p<0.05$ was applied.

Results

The ANOVA identified significant differences among groups for all ABB variables (Table 1). Specifically, CSS were taller than SYN which was evidenced by (*Scheffe's post-hocanalysis*). The SYN weighted less than CSS and CON groups ($p=0.01$), and had lower BMI and body-fat-percentage than CON. The CON had lowest percentage of muscle-mass ($p=0.01$) and had shortest forearm-length ($p=0.01$). The CSS had longest upper-limb length ($p=0.01$). The SYN had higher Ratio B compared to CSS and CON group ($p=0.01$).

Table 1. Descriptive statistics for anthropometric/body build indices and differences among groups calculated by analysis of variance (ANOVA) with corresponding Scheffe's post-hoc test significance

	SYNCHRONIZED SWIMMING (N=14)	COMPETITIVE SWIMMING (N=12)	CONTROLS (N=33)	ANOVA	
	Mean±SD	Mean±SD	Mean±SD	F test	p
BH (cm)	163.99±4.91 ¥	170.78±5.76	166.09±6.01	4.78	0.01
BM (kg)	50.13±7.73 ¥, £	61.01±5.57	58.48±10.07	5.94	0.01
BMI (kg/m^2)	18.44±2.23 £	20.88±1.6	21.24±3.66	4.26	0.02
BF (%)	16.09±4.8 £	21.83±5.24	26.43±7.49	12.54	0.01
MM (%)	36.05±2.1 £	34.73±2.25 £	31.7±2.96	15.28	0.01
ULL (cm)	74.6±3.06 ¥	80.09±2.44 £	73.86±3.41	17.58	0.01
FLL (cm)	43.49±1.42 £	44.93±1.56 £	37.43±1.88	113.20	0.01
Ratio B	0.58±0.02 ¥, £	0.56±0.01 £	0.51±0.02	145.66	0.01

Legend: BH – body height, BM – body mass, BMI – body mass index, BF – body fat, MM – muscle mass, RM – resting metabolic rate, ULL – upper limb length, FLL – forearm limb length, Ratio B – ratio between FLL and ULL, ¥ denotes significant post-hoc differences when compared to COMPETITIVE SWIMMING, £ denotes significant post-hoc differences when compared to CONTROLS

Table 2. ACE I/D genotype distribution in synchronized swimmers, competitive swimmers and non-athletic controls

group	ACE			Fisher exact test p
	DD	ID	II	
SYN (N=14)	35.7%	42.9%	21.4%	0.89
CSS (N=12)	33.3%	50.0%	16.7%	
CON (N=30)	23.3%	56.7%	20.0%	

The frequencies of ACE genotype in both groups of athletes as well as controls met HWE criterion. There were no significant differences in genotype frequencies between SYN, CSS and CON groups (p=0.891).

Discussion

Our study brings a few findings about ABB indicators that we will discuss in the following text. Authors Erlandson et al. (2008) reported that swimmers are taller than other athletes in different sports. Those results are in agreement to our findings that CSS group was taller than SYN and CON group. Swimmers need to be tall which a precondition for better sports performance. Study of Geladas et al. (Geladas, Nassis & Pavlicevic, 2005) revealed that tallness together with longer limbs is associated to better swim performance. This is indirectly confirmed in our study since we identified longest upper limb length in CSS. Meanwhile, Bogdanis et al. (Bogdanis, Chairopoulou & Maridaki, 2007) concluded that body height for synchronized swimmers should be similar with body mass and BMI lower when compared to age- and gender-matching non-athletic peers. Again, our results are supportive to such findings since SYN group had lowest BMI and body mass. For SYN we found similar findings as authors (Peric et al., 2012) in anthropometry parameters BH,BW and BF. Comparing synchronized swimmers with aesthetic sport athletes in the same age category, the aesthetic athletes are smaller and weighed less. Moreover, values BF in SYN group are similar with figure skaters (Monsma et al., 2005) and higher as in artistic gymnastics (Alessandra di Cagno et al., 2008) and aerobic gymnastics (Kyselovičova et al., 2016). We assume, that these findings are related to the external environment conditions where is the sports performance realized. On the land sport performance is influenced by gravity which is reduced in the aquatic environment. In short, body fat increase body buoyancy and higher values of BF can positively influence movements on and under the water surface to some extent (Peric et al, 2014).Analysis of ACE I/D polymorphism did not provide significant differences in genetic variation between synchronized and competitive swimmers, nor in comparison with the non-athletic controls. The small number of subjects in elite athletes groups could be the reason that the association of ACE I/D polymorphism with elite synchronized or competitive swimmers were not detected.

Conclusion

Differences in anthropometrics between SYN and CSS are clearly connected to specific sport-tasks and requirements. The sport of synchronized swimming requires low body weight associated with a lower percentage of body fat and longer forearm. Meanwhile, the body height and arm length are essential for sport swimming, as the basic factors determining the competitive performance in this sport. We did not provide evidence for significant differences of variation of the ACE I/D polymorphism between observed groups.

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OVERUSE INJURIES AMONG ELITE MALE ORIENTEERS IN ADOLESCENT CATEGORIES IN THE CZECH REPUBLIC

Chaloupská Pavlína
University of Hradec Králové, Czech Republic

Abstract

Orienteering is an endurance discipline where athletes run in the rough terrain from 30 to 60 minutes according to the racing discipline. Racing demands on performance have increased training load in children and adolescents in orienteering over the last decades. Children and adolescent differ from adults in many aspects, while the body size and body proportions change noticeably. Overuse injuries have become more frequent in this age group. The aim of this research was to determine the prevalence of injuries resulting from overload of the locomotor system in elite orienteering runners in the youth and junior categories (M18 and M20) in the Czech Republic. The survey was carried out in August 2017. The participants were elite male orienteers aged 16-20. It was assumed that in the Czech Republic there is a high incidence of locomotor injuries in adolescent orienteering categories, the majority of which can be classified as overuse injuries. The results of the research showed that in all diagnosed cases, knee or ankle were injured. The acute injuries were mainly direct traumas and ankle distortions and the incidence of overuse injuries was mainly in the knee. The research also monitored possible causes of the mentioned problems. The questionnaire survey confirmed the hypothesis and partly showed a relation to an early specialization. Other possible factors influencing the occurrence of injuries may be insufficient system of training methods in children, adolescents and junior categories in the Czech Republic and too long competition distances for boys aged 13-18. This research did not examine an influence of inadequate footwear or paved training terrain. It is apparent that many of the overuse injuries in adolescent orienteers are preventable. It should be the responsibility of coaches to become involved in their early diagnosis, treatment and prevention. The results support the author's recommendation to change the system of competition distances in the M16 categories in the Czech Republic.

Key words: *overuse injuries, orienteering, adolescent, training*

Introduction

Orienteering

Orienteering is an endurance discipline comprised of physical and cognitive components. The basic idea in orienteering is to proceed from course start to finish by visiting a number of control points in a predetermined order with a help of map and compass. Orienteering athletes compete on a timed run through unknown cross-country terrain, checking in at predetermined control sites while navigating with only a map and compass. An orienteer must navigate and make quick decisions while running at high speed through unknown cross-country terrain (IOF, 2017). The performance time varies from 15 to 70 minutes in junior categories according to the orienteering discipline. The aerobic fitness of elite orienteers is similar to that of elite athletes in other endurance sports because of a large amount of aerobic training (Creagh at al., 1997). Racing demands on performance have increased training load in children and adolescents in orienteering over the last decades. The racing time and possible volume in kilometers for these categories in Czech Republic is much higher than the racing volume for young track and field athletes (Table 1).

Table 1. Racing times and racing volume in children and adolescent categories (www.atletika.cz, www.orientacnibeh.cz)

category	racing time	approximate racing kilometer	track and field cross-country run
H14	40	Max. 6,5 km	3km
H16	50	Max. 8,5 km	4km
H18	60	Max. 12km	6/4km
H20	70	Max 14 km	6km

These racing volumes, along with inadequate methodical materials and non systematic training of youth trainers in the Czech Republic, may in some cases lead to high training volumes for teenagers and juniors.

Sport injuries

The aim of this paper was to determine the prevalence of injuries resulting from overload of the locomotor system in adolescent categories and search for the factors influencing their occurrence. Injuries are the most important performance inhibiting factor for all orienteers. A sports injury is defined as any physical complaint that is sustained from a sport activity that may or may not result in time loss from sports activities or in a medical consultation (Fuller, 2006). Sports injuries are further classified as traumatic or overuse injuries. Fuller (2006), defined a traumatic injury as an "injury resulting from a specific, identifiable event", whereas an overuse injury was described as one caused by "repetitive micro trauma without a single identifiable event responsible for the injury". Overuse injuries occur when a tissue is injured due to repetitive submaximal loading. The process starts when a repetitive activity fatigues a specific structure such as tendon or bone. Without adequate recovery, micro trauma develops and stimulates the body's inflammatory response, causing the release of vasoactive substances, inflammatory cells, and enzymes that damage local tissue (Fiori, 1999). Cheron et al (2016) defined 3 essential characteristics of overuse injuries for research purposes. First there must be a complaint, either simply noted by the athlete, or in terms of its consequences (e.g. medical attention and/or time-loss). Second there should be no single identifiable traumatic cause. Third there should be a history of repeated micro-trauma.

Increased intensity of sports activities combined with a decrease in daily physical activity makes overuse injuries in children more common. (Launay, 2015) In a study of children (aged 5 to 17) 49.5% of 394 sports injuries were classified as overuse, with boys and girls displaying a similar frequency. (Watkins & Peabody, P., 1996). Fiori (1999) defined the factors contributing to overuse injury in children. He classified intrinsic factors and extrinsic factors. Intrinsic factors are growth (susceptibility of growth cartilage to repetitive stress, inflexibility, muscle imbalance), prior injury, anatomic malalignment, menstrual dysfunction and psychological factors (maturity level, self-esteem). Extrinsic factors are too-rapid training progression and/or inadequate rest, inappropriate equipment/footwear, incorrect sport technique, uneven or hard surfaces and adult or peer pressure. Factors related to growth are particularly important. It is the susceptibility of growth cartilage to repetitive stress. The articular cartilage appears most vulnerable to injury at the ankle, knee, and elbow. Apophyseal injuries, including tibial tubercle apophysitis (Osgood-Schlatter disease) and calcaneal apophysitis (Sever's disease), are commonly attributed to overuse (Peck, 1995). Other common running overuse injuries are stress fractures, shin splint syndrome and chronic ankle instability. Most often the fractures caused by stress are located at the tibia and metatarsalia. Training, for example, is one of the extrinsic risk factors by shin splint syndrome, especially fast changes in amount or intensity, or changes of the running basement (Leumann et al., 2013). Shin splint syndrome often appears during spring, when the athletes change their training from basic endurance training to specifically competitive orienteering training. Typically, injuries are located on the medial side of the tibia (Leumann et al., 2013).

Injuries in orienteering

The rough terrain encountered in orienteering results not only in a high energy cost but also in a higher incidence of sport-specific injuries, particularly to the ankle. Minor injuries such as cuts and bruises are common during competition. (Creagh at al., 1997) Compared with long-distance running, a higher proportion of orienteering training takes place on rough ground and forest trails, which are likely to affect the injury profile. (Rosen at al., 2016)

Most recent prospective studies have been realized at orienteering competition events. Ekstrand (1990), Linko et al. (1997), Folan, (1982), Hintermann, B., & Hintermann, M. , (1991) and McLean (1990) registered injuries during 1 - 6-day events and identified an incidence rate of 7.3 injuries per 1000 competition hours , respectively 1.4 to 5.3 injuries per 100 orienteers. Most injuries occurred to the lower extremities (70%), and ankle sprains represented 23.9%-25% of all injuries. Similar results got Kujala at al. (1995) among Finnish orienteers, the lower limbs were involved in 73.6% of cases, the ankle (28.7%) and the knee (23.2%) being the two most common injury locations. Also elite level runners in Great Britain suffered mostly the knee (16%) and ankle (43%) injuries (Creagh et al., 1998).In all of these studies, the researchers identified mainly acute injuries; overuse injuries have received little attention recently. In addition, these reports have predominantly involved adult athletes. (Rosen et al., 2016).

Overuse injuries in orienteering were followed only in 3 studies. Linde (1986) followed 42 competitors over 1 year. A total of 73 injuries (average ¼ 1.7 injuries per orienteer per year) were reported; 52% of these injuries were acute, and 48% were overuse injuries. All overuse injuries were located in the lower extremities: diagnoses were medial shin pain, Achilles peritendinitis, peroneal tenosynovitis, and iliotibial band friction syndrome. Acute injuries most frequently occurred during the competitive season, whereas overuse injuries occurred most often during continuous training periods. Leumann at al., (2006a) followed athletes of the Swiss national orienteering team. His results are in accordance with other studies. In his research 73,6% of all injuries affected the lower extremity, thereof the most affected ones were the ankle (28,7%) and the knee (23,2%). Overall, 55,9%to 71% of all acute injuries were related to wounds and blisters, 1,2 to 13,2% to contusions and strains, 7,2 to 24,7% to acute ankle sprains, and 0,8 to 3,3% to fractures. His next study followed only chronic ankle instability and showed that 86% of all reported having had at least one or even more acute ankle sprains. Moreover, 73% of all athletes also showed signs of chronic mechanical and/or chronic functional ankle instability. (Leumann et al. 2006b). The most recent study determined the prevalence of injuries by registering acute and overuse injuries in adolescent elite orienteers over 26 weeks in Sweden. (Rosen et al. 2016). Its main finding was that overuse injuries were more common than acute injuries (78.0% versus 22.0%) among adolescent elite orienteers. The injury incidence was highest for the foot/lower leg (48.6%), and 71.6% of all injuries were located in the foot/lower leg together with the knee area. Training volume, competition time, running on asphalt roads, and running on forest surfaces and trails were associated with the time to the first reported injury (Rosen at al., 2016).

The Aim

The aim of this research was to determine the prevalence of injuries resulting from congestion of the locomotor system in elite orienteering runners in the youth and junior categories (M18 and M20) in the Czech Republic.

Methods

The survey was carried out in August 2017. The participants were elite male orienteers aged 16-20. The observed categories were M 18(age 16 and 17) and M 20 (age 18 and 19). The sample comprised 31 (man) – 14 in category M18 and 17 in M20. The main inclusion criterion was competition in elite categories M 18A or M20A in 2017. The total number of all active orienteers (they participated at least in 50% of all A classified competitions in the year 2017) in this categories is 63.

The main research method was a questionnaire. The questionnaire contained 15 items. The most important question surveyed the history of injuries during the orienteering career and the time of recovery. Next dimensions were related to the beginning of orienteering training, to the training amount in the categories H14, H16, H18 and H20 and to other sport activities.

For identification of overuse injuries a definition of overuse injuries by Cheron at al., (2016) was used. All data were compiled and analyzed in Excel (version 2016; Microsoft Corporation).

Results

In this survey 80% (n=25) participants got injured at least once. Only 20% (n=6) did not have any injuries during their orienteering career. 50 injuries were registered, 33 of them were classified as overuse injuries (66%).

Table 2 shows the prevalence of all the injuries. The most common acute injury was a sprained ankle 41% (n=7). The most frequent overuse injury was a knee pain 24% (n=8). We did not identify if the pain was caused by Osgood-Schlatter disease or due to other problem. The chronic ankle instability and stress fracture both occurred in 12% (n=4).

Table 2. Prevalence of all injuries in this research

Overuse injury	Absolute frequency	Acute injury	Absolute frequency
thigh	1	sprained ankle	7
heel pain	3	bruised knee	1
shin pain	3	fracture	2
foot	3	stab wound	1
knee	8	ruptured knee ligaments	1
hip/groin	3	ruptured thigh muscle	2
chronic ankle instability	4	toe inflammation	2
stress fracture	4	bruised shin	1
Achilles pain	3		
calf cramps	1		
Total	33		17

The questionnaire survey did not prove a causal link of early sport specialization and overuse injuries. But the results suggested that there was an early sport specialization in some cases. 19 respondents (61%) started to practice orienteering in the preschool age and 22 respondents (71%) started the regular training before the age of 14. The training volume varied between 1200 km and 5000 km a year. The maximal training volume in one training unit was in H14 25km, in H16 41km, in H18 35km and in H20 50km. The higher prevalence of overuse injuries in knee compared to other studies could refer to high training volume in categories H14 and H16.

Discussion

Our results are in accordance with those of von Rossen at al. (2016) and Leumann et al. (2006a) demonstrating that overuse injuries are more common than acute injuries in orienteering 66%, versus 34%. The results are in accordance with studies in several other sports for example those of Andersenat et al. (2013), Clarsen et al. (2014) and Ristolainen et al. (2010). Our results differ in prevalence of lower limb injuries at Leumanat et al. (2010) 73,6% versus our 98%. Similar results were reported by Roos et al. (2015): 93, 44% and Linde (1986): 100%. As in the systematic reviews of long-distance runners (Gent, 2007) and adolescent cross-country runners (Rauh et al., 2000) the authors have reported that knee, lower leg, and foot were the most common injury locations. Our results also differ in prevalence of ankle injuries 35%, Leuman86%. This difference may be due to the selection of the target group (our research – adolescent, research of Leuman – adults with long orienteering career).

The question is why the children and adolescent in Czech Republic undertake so high training volume. It may be linked with the racing time and volume in these categories (Table 1) on the one hand and to the lack of methodological information in Czech Republic on the other hand. In most cases the training differs from the recommendation of 25 training hours per week (Donnelly at al., 1993) In general, the 10,000 hours of training required to achieve the elite level of sporting performance are generally accepted. Out of this, about 4,000 hours of specialized training is to be done, but it should start earliest after the age of 14-17 years. Early sport specialization is a situation where children before puberty (12th to 15th year) start sport training and competition focused on just one sport in order to achieve the highest levels of performance (Šafář, 2012).

The statistical analyses had some limitations. The sample was limited, although 50% of all elite adolescent orienteers were interviewed. Concerning the limited number of data, risk factors associated with injuries could not be analyzed or a link to early sport specialization verified. This research did not examine an influence of inadequate footwear or paved training terrain.

Conclusion

The main finding of this study was that overuse injuries were twice more common than acute injuries (66% versus 34%) among adolescent elite orienteers in the Czech Republic. 88% of all injuries were located in the foot/lower leg together with the knee area. Specific for this study was the finding, that there was a high prevalence of knee overuse injuries in adolescent age (24% of all overuse injuries). The acute injuries were mainly direct traumas and ankle distortions. The results also showed, that there is a wide range in the training volume of the young orienteers in the Czech Republic. In some cases we could speak about early sport specialization. This problem could be solved by a new training methodology and a new system of education for Czech orienteering coaches. It should be their responsibility to become involved in early diagnosis, treatment and prevention of overuse injuries. The results support the author's recommendation to change the system of competition distances in the M16 categories in the Czech Republic.

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EFFECT OF HORMONE YOGA THERAPY ON SYMPTOMATIC MANIFESTATIONS OF DYSFUNCTIONS IN THE ENDOCRINE AND REPRODUCTIVE SYSTEMS

Chocholová Lucie, Vychodilová Renata, Pokorná Alena, Svobodová Zora
Masaryk University, Brno, Czech Republic

Abstract

The current research study was conducted to assess the effects of the application of the licensed motion intervention programme called Hormone Yoga Therapy (HYT) on 30 selected symptomatic manifestations of selected dysfunctions of the endocrine and reproductive systems. The respondents were 135 women who completed the Hormone yoga therapy (HYT) seminar in authorized HYT centres. 19 of the respondents had to be excluded from the study as they were using hormonal contraceptives or did not practice sufficiently. The remaining 116 respondents were divided into group 1 (n=61, age 19-35 years) and group 2 (n=55, age 36-55 years). The HYT practice included postures (asana), breathing techniques (pranayama) and relaxation. Significant improvements were observed in some of the 30 chosen symptomatic manifestation of dysfunction in the endocrine and reproductive systems. The practice of HYT was concluded to be potentially helpful in improving of symptomatic manifestations such as mood changes, physical exhaustion, anger, constipation, premenstrual syndrome, anxiety and misery flushes, back pain, and libido decrease. However, further research with a larger sample size is recommended for better understanding of the mechanism of the effects on the selected disorders of reproductive and endocrine system.

***Key words*.** Hormone yoga therapy, dysfunction of endocrine system, dysfunction of female reproductive system, infertility, climacteric syndrome

Introduction

There is growing evidence that yoga may be an effective intervention for treating symptomatic manifestations of dysfunctions in the endocrine and reproductive systems, such as menopausal symptoms (Booth-LaForce, Thurston, & Taylor, 2007; Joshi & Vaze, 2010), low female sex hormone levels and low parasympathetic activity (Khadka et al., 2013), hypothyroidism and high cholesterol (Nilakanthan, Metri, Raghuram, & Hongasandra, 2016), decreased cognitive functions in climacteric syndrome (Chattha, Nagarathna, Padmalatha, & Nagendra, 2008),and insomnia (Afonso et al., 2012).

Other findings indicate beneficial effects of yoga in glycaemic control by increasing the percentage of insulin binding receptor in type 2 diabetic patients (Gordon et al., 2008). However, no research on the effects of yoga on dysfunctions and insufficiencies of the endocrine and reproductive systems has been conducted, apart from a small number of cases studies (Booth-LaForce et al., 2007; Chattha et al., 2008; Nilakanthan et al., 2016; Rani et al., 2013).

There are many disorders related to changes in hormones, such as menstrual disorders, polycystic ovary syndrome, premenstrual syndrome, infertility, acne, orosteoporosis (Daley, Stokes-Lampard, & MacArthur, 2009).

The deficiency of estrogen or progesterone is associated with the absence of ovulation and dysfunctional menstrual cycles. Ovulatory dysfunction is one of the most common cause of female infertility. Elevated androgens in a woman‘s body cause polycystic ovary syndrome that consists of 28 clinical symptoms, which include various types of menstrual disorders, acne and difficulty getting pregnant. Also, it could be associated with type 2 diabetes, obesity, insomnia, heart disease, and mood disorders (Palioura & Diamanti-Kandarakis, 2013).Unusual changes in hormone levels during a woman‘s period are often associated with premenstrual syndrome (PMS). It is a set of physical, physiological, and emotional symptoms such as acne, tender breasts, bloating, tiredness, anxiety, anger, exhaustion, depression, nausea, headache, libido decrease, weight gain, insomnia, and mood changes. It is estimated that 20 – 30% of pre-menopausal women are affected with PMS (Porth, 2008; Rokyta, 2008; Silbernagl, Despopoulos, Gay, & Rothenburger, 2004).

The production of hormones in ovaries is decreased physiologically during menopause, while women often experience some of climacteric symptoms such as hot flushes, sweating, vaginal dryness, trouble sleeping, mood changes, heart disease, anxiety and misery flushes, anger flushes, weight gain, reduced blood flow to the limbs, insomnia, physical exhaustion, loss of hair strength, gingiva recession, headache, nausea, joint ache, swollen limbs, tingling in the limbs, carpal tunnel syndrome, hair loss, back pain, shortness of breath, constipation, migraine, increased heart rate, itching and burning of mucous membranes, and osteoporosis (Porth, 2008; Rokyta, 2008; Silbernagl et al., 2004).

Thus, the aim of the study is to assess the efficacy of the Hormone yoga therapy on symptomatic manifestation of the endocrine and reproductive systems depending on age, duration of involvement in the HYT programme, and week frequency of exercising.

Methods

Respondents. Through cooperation with HYT instructors and authorised centres that teach this method, I addressed women of various age groups and with varying symptomatic manifestations and dysfunctions from the entire Czech Republic who completed the Hormone yoga therapy (HYT) seminar in the authorised HYT centers and practice HYT in these centers. Furthermore, I shared an electronic version of the questionnaire on social networks in groups that bring together women who completed an HYT course. The questionnaire was completed by 135 respondents of different age groups with various symptomatic manifestations and dysfunctions. Of a total of 135 respondents, 19 of the respondents had to be excluded from the study as they were using hormonal contraceptives or did not practice sufficiently. The remaining 116 respondents were divided into group 1 (n=61, age 19-35 years) and group 2 (n=55, age 36-55 years) (Table 1).

Table 1. Age distribution of respondents

Age of respondents	Absolute frequency	Relative frequency	Cumulative frequency	Relative cumulative frequency
19 - 35 years	61	52.59 %	61	52.59 %
36 - 55 years	55	47.41 %	116	100.00 %

Study design. The introduction of the questionnaire included written informed consent, where the study was explained in detail to the respondents in their mother tongue. The questionnaire consisted of 37 closed questions and the survey took two months, March and April 2017. Besides general questions relating to age, passing an authorized HYT seminar, and the length and frequency of practice, the respondents were also required to answer specific ones related to symptom changes (the choice of answers was as follows: *Not affected* or *Large deterioration* or *Mild deterioration* or *No change* or *Mild improvement* or *Lange improvement* or *Disappearance of the symptom*) and pharmalogical treatment such as hormonal contraceptives, hormone replacement therapy orantidiabetics (the choice of answers was as follows: *I did not undergo this treatment* or *Increased* or *Not changed* or *Decreased* or *I have stopped undergoing this treatment*).

Assessments. To process the obtained data, the descriptive analysis and the inferential statistic method of chi-squared distribution were applied. Using descriptive analysis, we aimed to answer the following research questions: *Which ten symptoms were the most improved by HYT?, What is the relative frequency of getting pregnant in case of women that claimed to be infertile?* and *Do the result confirm the expectation* *that women under hormone replacement therapy may decrease or stop taking medication?*. Using inferential statistic method of chi-squared distribution, we verified and evaluated following hypotheses: *The symptomatic manifestations are independent upon the age of the respondents*, *In the symptoms that affect more than 50 % of the respondents, the symptomatic changes are independent upon frequency of exercising of the HYT*. and *In the symptoms that affect more than 50 % of the respondents, the symptomatic changes are independent upon the duration of application of the HYT.*

*Interventions***.** Under the guidance and supervision of qualified HYT instructor, all respondents completed an HYT course. All subjects performed Hormone yoga therapy at least longer than for one month and more often than once a week. Hormone yoga therapy has several steps such as: combination of physical exercises (asana) and breathing techniques (bhastrika pranayama, ujjayi pranayama), gestures (nasikagra drishti, khechari mudra), internal locks (jalandhara bandha, moola bandha and uddiyana bandha) and meditation techniques (yoga nidra). There are some extra anti-stress exercises based on relaxation. An important part of the whole practice is visualization and imagination connected with the healing process. According to Rodrigues, the most important technique used in HYT is Circulation of energy (CE) which is used in nearly every exercise (Rodrigues, 2014).

*Analysis***.** The questionnaire included 30 selected examined symptoms (hot flushes, mood changes, anxiety and misery flushes, anger flushes, weight gain, vaginal dryness, reduced blood flow to the limbs, insomnia, physical exhaustion, loss of hair strength, gingiva recession, acne, headache, nausea, joint ache, swollen limbs, tingling in the limbs, infertility, carpal tunnel syndrome, irregular menstruation, hair loss, back pain, shortness of breath, constipation, libido decrease, migraine, increased heart rate, itching and burning of mucous membranes, premenstrual syndrome (PMS), polycystic ovary syndrome (PCOS). In each symptom the answered question divided the respondents into 7 groups (*Not affected* or *Large deterioration* or *Mild deterioration* or *No change* or *Mild improvement* or *Lange improvement* or *Disappearance of the symptom*) according to the changes in their symptomatic manifestation. Besides questions about symptoms, it was also investigated whether respondents were taking certain hormonal preparations (hormone replacement therapy and hormonal contraception) or antidiabetics.

Statistical analysis was done by using of descriptive statistic and in some chosen cases, it was contrasted with inferential statistic to make statistical proposition and reject or accept the hypotheses. As for the tool of inferential statistic, the chi-squared distribution was applied.

Results

The results show that the intervention HYT programme had the greatest effect on the following symptoms: mood changes (85.51%), physical exhaustion (79.52%), anger (77.78%) and hot flushes (77.78%), constipation (76.92%), premenstrual syndrome (75.81%), anxiety and misery flushes (75.47%), back pain (75.32%), carpal tunnel syndrome (71.43%) and libido decrease (70.13%). In relation to the listed symptoms, the respondents claimed to feel an improvement of their symptoms or their disappearance in the majority of cases after undergoing the HYT intervention (Table 2).The results also show that intervention programme was effective in the field of fertility (Table 3).

The results confirm the expectation that some women under the hormone replacement therapy may stop taking their medication. Out of 16 respondents, 10 women (62.50%) reported they stopped taking medication altogether.

Further, it can be concluded that on the level of significance α = 0.05, the symptomatic manifestations are dependent on age of the respondents.

Table 2. Ten symptoms that were the most improved by HYT

Symptom	Out of	Of affected women		
		Improvement	Disappearance	TOTAL improvement
Mood changes	69	76.81%	8.7%	**85.51%**
Physical exhaustion	83	73.49%	6.02%	**79.52%**
Anger flushes	54	72.22%	5.56%	**77.78%**
Hot flushes	27	59.26%	18.52%	**77.78%**
Constipation	39	71.8%	5.13%	**76.92%**
Premenstrual syndrome (PMS)	62	69.36%	6.45%	**75.81%**
Anxiety and misery flushes	53	66.04%	9.43%	**75.47%**
Back pain	77	66.23%	9.09%	**75.32%**
Carpal tunnel syndrome	14	57.15%	14.29%	**71.43%**
Libido decrease	77	62.33%	7.79%	**70.13%**

Table 3. Frequency of infertility occurence

INFERTILITY	Absolute frequency	Relative frequency	Cumulative frequency	Relative cumul. Frequency
Large deterioration	0	0,00%	0	0,00%
Mild deterioration	0	0,00%	0	0,00%
No changes	37	62.71%	37	62.71%
Mild improvement	2	3.39%	39	66.1%
Large improvement	4	6.78%	43	72.88%
I`ve got pregnant	16	27.12%	59	100,00%
TOTAL	59	50.86%		

Regarding the ten most frequent selected symptoms (physical exhaustion, back pain, libido decrease, mood change, irregular menstruation, weight gain, premenstrual syndrome, infertility, hair loss, and loss of hair strength), on the level of significance $\alpha = 0.1$, only in the case of infertility, the research conclusively proved correlation symptomatic improvement and the frequency of exercising. It can be further concluded that on the level of significance $\alpha = 0.1$, the symptomatic changes of losing hair strength, weight gain and back pain are dependent on the time of being involved in the HYT programme.

Discussion

HYT intervention based on yoga poses, breathing techniques and relaxation techniques may improve the symptomatic manifestations of selected disorders of reproductive and endocrine functions. This suggests that HYT intervention produces favorable effects in individuals with climacteric syndrome, menstrual disorders, Polycystic Ovary Syndrome, Premenstrual Syndrome and infertility.

The strengths of the study are the mapping of a wide range of symptomatic manifestations across age groups of women, demonstration of the influence of yoga on physical and mental fitness, and outlining the direction of further studies that could deal with this or similar topic.

Limitations of this investigation were wide age range of the respondents and differences in frequency and duration of practicing the HYT programme. The sample size was not large enough to analyze women in menopause and women of fertile age separately.

Although the research was initially very extensive, the number of symptoms examined broke the group down into smaller subgroups whose individual results were not of a completely predictive value. The extent of the conducted survey did not give space for examining details in greater depth. The varying frequency and duration of practicing the intervention programme caused that the group was very heterogeneous. So was the age range, which included women of fertile age, as well as age bordering on the menopause.

Conclusions

Based on the responses received and their subsequent analysis, I presented the results in the form of answers to the research questions and of the confirmation or rejection of the hypotheses.

The HYT may produce favorable symptomatic changes in individuals with symptomatic manifestations of selected dysfunctions of the endocrine and reproductive systems. In the case of infertility, the research conclusively proved correlation between symptomatic improvement and the frequency of exercising. It can be further concluded that the symptomatic changes of losing hair strength, weight gain and back pain are dependent on the time of being involved in the HYT programme.

Further research with a larger sample size is recommended for better understanding of the mechanism of the effects on the selected disorders of reproductive and endocrine system. The priority should be given to stricter and clearer criteria, and homogeneous groups with the narrowest possible age range should be preferred. In addition, the questionnaire should be designed to produce more specific research data. If the survey also included overall medical history, it would allow the research to take into account also their lifestyle, diet and body type. In collaboration with physicians, the medical diagnosis and blood test data of the respondents should be included, if available, in the research. To ensure higher information value, a control group would be formed in addition to the experimental group and used for subsequent comparison of obtained data.

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THE IMPLICATIONS OF RESPIRATORY MUSCLE TRAINING IN PROFESSIONAL ATHLETES

Machova Lucie[1], Zatloukal Jakub[3], Stejskal Pavel[1], Poděbradská Radana [1,2]
[1]Faculty of Sport Studies, MU Brno
[2]Rehabilitace Lipová-lázně
[3]Pulmonary Rehabilitation Department, University Hospitals of Leicester NHS Trust, Leicester, United Kingdom

Introduction

Respiratory muscle training, even if used in the sports medicine, should be applied according to its basic methodological principles. Failure to adhere to these principles may present detrimental consequences to the musculoskeletal system. It may result in temporary functional impairment and muscle imbalances causing deterioration in technique of a sport-specific movement activity, overall decline in performance or decelerated training progression, which all may later develop into permanent changes.

Currently, there is a wide selection of various devices that can be used for the respiratory training. Consulting physiotherapist should help selecting the most appropriate resistive breathing device. Physiotherapist examines the breathing pattern and respiratory muscle strength by testing the maximal inspiratory and expiratory mouth pressures. Another important part of the assessment is an evaluation of posture in various positions and ability to activate of the deep muscle stabilizing system, in which the dominant postural function presents a diaphragm muscle. Should there be an impairment in one of the diaphragm functions (breathing or postural), it is likely to impact on the other function as well (Neumannová,2013) and therefore individually prescribed and tailored techniques for the activation of the deep muscle stabilizing system should be applied altogether with the respiratory training using an appropriate resistive breathing device based on the findings from the initial assessment with physiotherapist.

Breathing pattern should be optimised first to avoid any overload of accessory breathing muscle which could result in muscle imbalances typically affecting muscles of the cervical spine, head and shoulder girdle. Common musculoskeletal symptoms of impaired breathing pattern are cervicocranial and cervicobrachial syndrome resulting in a pain of the cervical spine region and headaches. Lo et all (2011) wrote about thoracic outlet syndrome (TOS) and exercises intervention as a important part of management of therapy TOS.

It is well known that the requirements of respiratory system are quite extensive during vigorous activity and can reach up to 18 % of the maximum heart rate volume per minute. Harms (2007) wrote about metaboreflex too. Due to the high sympathetic activation, the blood flow through the exercising muscles becomes significantly reduced. This is described as respiratory metaboreflex, which is supposed to protect the organism from overloading. Reduction in blood flow results in a limited supply of oxygen and insufficient wash out of metabolites originating from the vigorous activity (Witt at al., 2007). All these factors impact on overall performance. Sheel et al (2001) defines metaboreflex as a consequence of the weakening of inspiration muscles and therefore recommends inspiration muscle training as a preventative strategy. However, this approach is not exactly correct as the expiratory phase should be also included in the training to ensure an optimized position for the following inspiration.

Respiratory training should be ideally applied to the specific sport. Thus, even the resistive breathing device should be suitable for the specific type of sporting activity, and should also take into account the quality of athlete's postural activation and breathing pattern. Respiratory training alongside with the use of breathing masks for resistive breathing is commonly used in sports medicines a training component. It should not be, however, regarded as a substitution for an alpine training, where the human body adapts to a low partial pressure of oxygen. Resistive breathing devices do not imitate this alpine environment; they are only increasing more or less the breathing effort.

Treshold PEP

Powerbreath

Spirotiger

Breathing masque

Key words: *Respiratory training, breathing pattern, breathing device, sport training*

Case study

Sport gymnastics is a speed-endurance physical activity and a gymnastics six apparatus includes various supportive and jumping exercises using tools like floor, pommel horse, gymnastic rings, vault, parallel bars and horizontal bar with the exercise session lasting usually around 90 seconds. These gymnastic exercises present high demands on muscle coordination and optimal postural stability. Gymnasts usually use Valsalv's maneuver for stabilizing the body during these extreme exercises, which suppresses the endurance ability of the sporting performance.

Professional gymnast (19 years of age), competing in gymnastic all apparatus and preparing for a world gymnastic championship. In his past medical history, he reported only common childhood diseases and a fracture of a styloid processus of left fibula. At the time of his initial assessment he was complaining of a pain in the lumbosacral region (with no irradiation), medial portion of his left knee, groin and left shoulder. He was also complaining of a feeling that he is not having enough air during his gymnastic performance and that it feels difficult to take a deep breath in.

Objectively, there was found a pathological breathing pattern with the overuse of the upper stabilizing muscle of the scapula and scalene muscles. He was not able to sufficiently activate a diaphragmatic breathing. His postural activation was sufficient in horizontal positions, but impaired in vertical positions. Further examination revealed a pelvic torsion with a shift of the sacroiliac joint to the right side, diminished lumbar and thoracic curvature of the spine, abnormal placing of shoulder joints and hyperextension of the knee joints. Overall, generalized hypermobility was diagnosed.

Chest expansion: M = 4.5 cm, X = 3 cm, 1/2X-U = 3.5 cm
Cardiopulmonary exercise test: VO2max = 33 ml/kg/min, max load = 3.5 W/kg
Maximal mouth pressures: PImax = 71 % predicted, PEmax = 66 % predicted
Objective of the therapy was to design compensatory programme for this athlete.

Each session lasted 90 minutes 3 consecutive days on a monthly basis over the period of 5 months. Therapy consisted of soft-tissue techniques with the aim to optimize and restore chest expansion, localized breathing techniques focused on the diaphragmatic type of breathing. Furthermore, stability of shoulders, pelvis and spine were addressed with stabilizing exercises originating from the developmental kinesiology, as well as core muscle exercises with eccentric activation. Jumping and landing practice with focus on posture positioning was included for preventative and compensatory reasons. Introduction and demonstration into the use of the resistive breathing devices (Threshold PEP and Threshold IMT) was delivered on the first session. Respiratory training was performed in sitting down position with upright back and elbows anchored on the table. Each device was to be used for 4 minutes initially which was increased by a minute after 4 days. The intensity was gradually increased by 1cmH2O each week.

During the following sessions, exercises were checked and corrected and some new progressions were introduced. Breathing exercises with the resistive devices were implemented using challenging postural situations from the developmental kinesiology. In postural situations requiring accentuation of the eccentric contraction of core muscles the Threshold IMT breathing device was used primarily, otherwise it was always both Threshold devices.

More challenging situations were gradually introduced into the therapy, e.g. balancing platforms and movements practice with elastic bands using methods from the dynamic neuromuscular stabilization concept. But also the basic gymnastic bodyweight exercises were included with a focus on breathing pattern and movement control through the optimal muscle activation.

Results

Designing a postural-respiratory programme and incorporating it in athlete's training resulted in quicker and improved activation of the deep muscle stabilizing system.

Subjectively, the athlete was no longer complaining about the pain from the lumbar-sacral region and from the sacroiliac joint. Similarly, the shoulder pain almost disappeared and was perceived only in highly demanding activities like for instance when working on gymnastic rings. Also pain in elbows was reduced and was present only in challenging situations where elbows were forced into biomechanically disadvantaged positions. Exertional breathlessness and sensation of restricted breathing were significantly reduced and overall, athlete was reporting feeling better and less limited when performing.

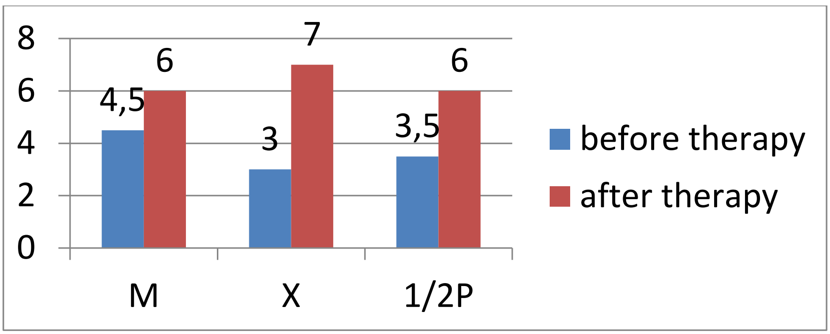
On discharge after 5 months of therapy, almost all of the tested variables were improved.

Chest expansion: M = 6 cm, X = 7 cm, 1/2X-U = 6 cm

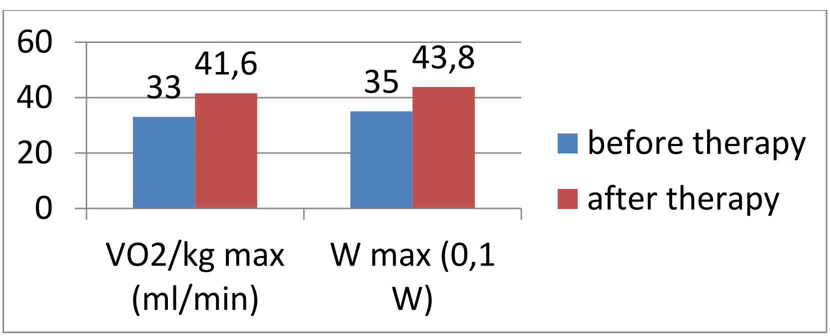
Cardiopulmonary exercise test: VO2max = 41.6 ml/kg/min, max load = 4.38 W/kg

Maximal mouth pressures: PImax = 96 % predicted, PEmax = 44 % predicted

Chest expansion (cm)



Cardiopulmonary exercise test



Maximal mouth pressures (%)

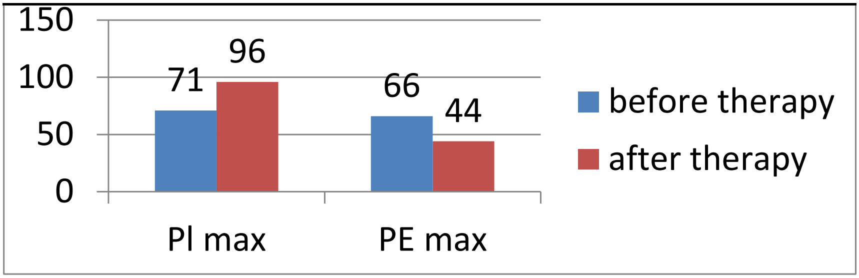


Figure shows comparison for a handstand hold position before and after the 5-month therapy. Handstand holds are one of basic gymnastic elements that athletes are learning from the very young age. It can be defined as a strength skill from the kinesiological perspective that requires optimal whole body muscle activation and control of balance.

Discussion

Relatively frequently seen condition among athletes is bronchial asthma. Neumannova (2011) advices that the therapy should be targeting the key component including the structural and functional impairment, therefore not only treating the respiratory condition, but also the functional component of the breathing movement. Thus, multidisciplinary cooperation is required for maximizing potential benefits of the training/therapy.

Each athlete shows functional disturbances within the musculoskeletal system due to a movement overload depending on a sporting activity, which differs and in every sport. Accessory breathing muscles like pectoralis muscle and serratus anterior also participate in arm movements in both open and closed kinematic chains. An extensive overload in these muscles can therefore negatively impact on breathing pattern and cause myofascial disturbances. If an athlete is chronically exposed to such an overload including high demand on respiratory system, it may also give a perception of a stinging sensation on chest, chest pain or even cause a blockage of a rib, etc. But all these symptoms already present significant limitations in athlete's performance and for this reason it is important to understand the sport-specific biomechanical requirements and as a compensatory approach incorporate elements of the respiratory physiotherapy into athlete's training.

Presented case study of our professional gymnast shows that tailored therapy applied onto athlete specific needs and combined with techniques of the respiratory physiotherapy leads to reduction of his symptoms and enhancements in his performance.

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BREATHING PATTERN OF RESTFUL AND DEEP BREATHING

Malátová Renata[1], Bahenský Petr[1], Mareš Martin[1], Rost Michael[2]
University of South Bohemia, Pedagogical faculty, Department of Sports studies, České Budějovice[1]
University of South Bohemia, Faculty of economics, Department of Applied Mathematics and Informatics, České Budějovice[2]

Abstract

Purpose: Respiration is a central aspect of our entire being. We know that every activity of the body is closely connected with breathing and the quality of breathing functions is decisive for our health. Current way of life with sedentary occupation and passive leisure result in the fact that today's civilization cannot breathe correctly (Haichová & Yesudian, 2014). The aim of this work was to investigate the course of breathing waves during restful and deep breathing in healthy individuals aged 19-25 who regularly engage in some sort of sports activity.

Methods: To test breathing stereotype in 163 research participants, we used a muscle dynamometer to monitor the dynamics of breathing activity. During analysis of the respiratory movements was based on the concept of three sectors of the chest. In the lower chest sector, the first muscular dynamometer probe was located. The second probe was placed in the middle chest sector and the third probe was placed in the upper chest sector. The breathing dynamometry test was performed in the upright position. With the probes we recorded individual segment movements for one minute during restful breathing and for one minute during deep breathing. In this way, 600 values were recorded for each person from one sensor during breathing at rest. The same number of values was also acquired in deep breathing. The time series thus obtained were then smoothed by the robust locally weighted regression method. Separate ranges and minima (local extrema) were subsequently identified in the evened series. From the values thus obtained, the average of the maximum and minimum for each individual was determined, depending on the location of the sensor and the type of breathing. From these values, the "average difference" for each sensor location and respiration type was determined for each individual. To test normality, the Shapiro-Wilk's normality test was used for each variable. Results are interpreted with 95% confidence. Due to the rejection of the zero hypothesis on data normality, Wilcoxon's pairing tests were used for individual variables in case of verifying the hypothesis of median compliance (or compliance of distribution functions). Numerical results were obtained through MS Excel and R 3.3.0 software.

Results: The values for restful breathing were statistically significantly lower on all sensors than those for deep breathing. During comparison of the percentage

involvement of individual chest sectors the activity of breathing waves predominates in the middle and upper chest sections over the activity of the lower chest section. During deep breathing the activity is reduced by nearly 10%.

Conclusion: On the basis of the results it can be concluded that the test individuals suffer from respiratory stereotype disorder.

Key words: *breathing waves, breathing sectors, diaphragm, breathing pattern disorders.*

Introduction

Breathing is a central aspect of our entire being and one of the most important life functions. Breathing exercises are historically linked to the emergence and the development of physical education schools, philosophical trends or various cultures, but we also find them in connection with medical sciences (Štumbauer, Tlustý, & Malátová, 2015). Since the turn of the century, western medicine has taken note of the important role of breathing in our health (Clifton-Smith & Rowley, 2011). Recently, research has revealed the vital role of breathing in our health as well as in our diseases (Gosselink, 2004; Courtney, 2009; Chaitow, Bradley, & Gilbert, 2014). The concept of dysfunctional breathing or breathing pattern disorders (BPD) has been defined to describe the incorrect forms of breathing stereotypes causing various symptoms (Clifton-Smith & Rowley, 2011). At present, there is an increasing interest in the impact of respiratory dysfunctions on common health problems such as asthma, chronic back pain and headaches, postural stability, cardiovascular diseases, anxiety and depression. Therefore, breathing therapies are increasingly used as a component of the healing methods of the aforementioned health problems (Courtney, 2009). Holistic manual therapy has long recognized dysfunctional breathing as a common disorder, which, if untreated, can have a major effect on the function and structure of the body. It is also noted that although breathing stereotype disorders are common, they are often overlooked and, if not detected and treated, lead to unnecessary complications in the medical condition (Courtney, 2009; Chaitow, Bradley, & Gilbert, 2014).

Breathing movements are accompanied by three different processes. The first one is the mechanical process – it is the mechanics of breathing movements. The second one is the physiological process involving gas exchange and central nervous system irritability changes. The last process that occurs during breathing movements is the controlling process. It is the management of breathing and postural movements with the involvement of the nervous system, including the effect on the psyche, muscles and internal organs (Véle, 2012; Dixhroorn, 1994). Breathing movements are rhythmically repeated in two phases: inspiration (inhalation) and expiration (exhalation). Exhalation has an inhibitory effect on the muscular activity of the postural-locomotive system and can be increased by holding the breath before inspiration. On the contrary, inspiration has an excitatory effect and can also be increased by holding the breath before expiration. Transient short periods between the inspiration and expiration are called preinspirum and preexspirum (Véle, 2006; Smolíková & Máček, 2010).

Both the rib cage and the abdomen are activated with proper breathing. In the ideal situation when inhaling (due to the decrease of the diaphragm position that exerts pressure on the abdominal cavity), the abdomen is slightly expanded (especially the upper parts), then the chest cage opens to the sides and the chest begins to slightly open on the front at the top – we are talking about the respiratory wave. The respiratory wave gradually passes through all three breathing sectors of the chest, the abdomen (from the diaphragm to the pelvic floor), the lower chest (from the diaphragm to the fifth thoracic vertebra), the upper chest (subclavicular, from the fifth thoracic vertebra to the cervical spine) (Kolář et al., 2009). The abdominal sector is responsible for 60% of the total breathing efficiency, the thoracic sector is responsible for 30% of the total breathing efficiency and the subclavicular sector for 10% (Šponar, 2003; Koťová et al., 2014). The percentages given apply to most activities during the day. These ratios change significantly in various types of exercises or some (pathological) changes in the organism, (Šponar, 2003). Similarly, Kaminoff (2006) states that normal breathing involves synchronized movement of the upper chest, lower chest and abdomen. In addition, normal breathing requires adequate diaphragm engagement (Pryor & Prasad, 2002). According to Kolář et al. (2009), the diaphragm itself is able to provide 75% of the intrathoracic space change when breathing is quiet and is sufficient for the ventilation of 2/3 of vital lung capacity. Dylevský (2009) states that the diaphragm itself will provide 60% of the volume of inhaled air. Its share in breathing is the reason why it is considered the most important muscle right after the heart.

Abnormal breathing involves breathing in the upper chest, with a visible increase in upper chest mobility when compared with the lower chest (Chaitow, Bradley, & Gilbert, 2002). Breathing stereotype disorders are defined as inappropriate breathing that is so persistent that it causes changes in the organism without apparent organic cause (Vickery, 2008). Breathing stereotype disorders are present in various individuals with a musculoskeletal disorder (Chaitow, 2004; Kapreli et al., 2009; Perri & Halford, 2004; Roussel, Nijs, & Truijen, 2007; Smith, Russell, & Hodges, 2006) and can be a risk factor for the development of the dysfunction or may be the result of the dysfunction itself. In individuals with discomfort and aches of musculoskeletal origin, we should always assess also the possible breathing pattern disorder (Bradley & Esformes, 2014).

Various methods such as palpation examination of breathing, whole body plethysmography, chest X-ray scan, spirometry, or various devices recording the change of the lift of individual segments of the trunk can be used to assess the breathing stereotype (Cahalin, 2004; Kandus & Satinská, 2001; Lewit, 2003). Involvement of the individual muscular segments is possible, e.g. through a 3-dimensional system (Kaneko & Horie, 2012). Burgos-Vargas et al. (1993) measured the circumference of the chest expansion using a measuring tape on the fourth intervertebral space (arms in the elevated position). A study by Bockenhauer et al. (2007) has confirmed that measurement using a measuring tape is objective for the examination of chest movements in the middle and upper thoracic sector. Véle (1997) states that the volume of breathing capacity is evaluated using spirometry or by measuring the diameter of the chest between the peak inspiration and the expiration in the lower or middle respiratory segments.

The aim of this study was to investigate the respiratory wave pattern, activation of individual thoracic sectors, using a muscle dynamometer during resting and deep breathing. In 2007, Malátová et al. confirmed that muscle dynamometer is able to objectively evaluate the condition of the muscles in the deep stabilisation spinal system (DSSS). As the diaphragm, as the main respiratory muscle, is a part of DSSS, muscle dynamometer was used for the investigation of respiratory movements. This device can detect the activation of respiratory muscles. Thus, the magnitude of the force and its dynamics can be evaluated. There are no previous studies investigating respiratory movements using this method.

Methods

The study included 163 healthy students of the Pedagogical Faculty of the University of South Bohemia in the programme of Physical Education and Sports (TVS) at the age of 19–25. We assumed that those students who regularly do sports and are familiar with the theory from physical education and sports, and principles of healthy movement, would be able to correctly activate all three breathing sectors during the respiratory wave. A research question was asked as to whether TVS students would activate individual breathing sectors at a given percentage representation in relation to the overall breathing efficiency both during breathing at rest and deep breathing. Where the abdominal breathing is responsible for 60% of the total breathing efficiency, the thoracic sector is responsible for 30% of the total breathing efficiency and the subclavicular sector for 10% (Šponar, 2003; Koťová et al., 2014). Furthermore, we assume that the acquired results during the measurement at rest will be lower than the values during deep breathing.

We used a muscular dynamometer to examine the breathing stereotype MD03 (Malátová, Rokytová, & Štumbauer, 2013). The probe locations were selected based on the kinematics of the mentioned thoracic sectors (Dylevský, 2009; Malátová & Bahenský, 2016). Using bands, one probe was fixed in each sector. The first muscular dynamometer probe was located in the lower thoracic sector on the ventral side at the L4-5 level. A second probe was placed in the middle thoracic sector on the ventral side at the level of the 8th to 9th ribs and a third probe was placed in the upper thoracic sector on the ventral side in the area of sternum at the level of the 3rd to 4th ribs (Dylevský, 2009). The breathing dynamometry test was performed in an upright position. The vertical position is physiological for breathing (Smolíková & Máček, 2010). Using the probes, we recorded the lift of individual segments for one minute during breathing at rest and during deep breathing for one minute. The same measurement procedure was used for deep breathing. Subjects were instructed to breathe as usual both during the breathing at rest and deep breathing. This provided 1800 values during breathing at rest for each person. The same number of values was also acquired in deep breathing. The obtained time series were then smoothed using robust locally weighted regression method. Separate ranges and minima (local extrema) were subsequently identified in the even rows. The acquired values were used to determine the average of the maximum and minimum for the individual subject depending on the location of the sensor and the type of breathing. The "average difference" for each sensor location and breathing type was determined for each subject from these values. Shapir-Wilk's normality test was used for each variable to test normality. Results are interpreted with 95% confidence. Due to the rejection of the zero hypothesis on data normality, Wilcoxon's pair tests were used for the individual variables for verifying the hypothesis of median equality (or compliance of distribution functions). Numerical results were obtained through MS Excel and R 3.3.0 software.

Results

Table 1. Percentage of involvement of individual thoracic sectors during breathing at rest.

n=163	Location of the sensor		
	lower thoracic sector	middle thoracic sector	upper thoracic sector
Average difference	0.2965364	0.3486856	0.3764308
Relatively in%	29.02516	34.12956	36.84528

Table 2. Percentage of involvement of individual thoracic sectors during deep breathing.

n=163	Location of the sensor		
	lower thoracic sector	middle thoracic sector	upper thoracic sector
Average difference	0.5477625	1.3253391	0.9909931
Relatively in%	19.12515	46.27428	34.60057

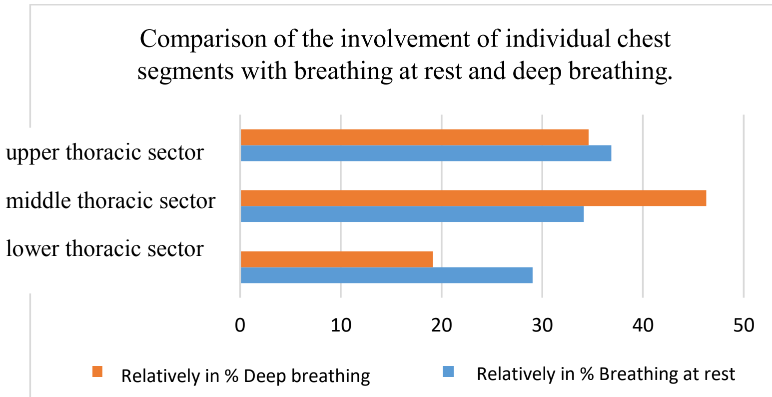

Figure 1. Comparison of the involvement of individual chest segments with breathing at rest and deep breathing.

When comparing the percent involvement of the individual chest sectors in the respiratory wave, the activity of the middle and upper chest sections prevails above the lower chest section. 10% activity limitation occurs during deep breathing in the lower chest sector.

The following table shows the results of normality tests for individual variables – i.e. The location of the sensor (lower, middle and upper thoracic sector) and the types of breathing (resting, deep):

Table 3. Results of normality tests for individual variables.

Breathing type	Location of the sensor	W	p-value
Breathing at rest	lower thoracic sector	0.71138	$< 2.2.10^{-16}$
Breathing at rest	middle thoracic sector	4.836	$4.836.10^{-12}$
Breathing at rest	upper thoracic sector	$7.075.10^{-9}$	$7.075.10^{-9}$
Deep breathing	lower thoracic sector	0.5864	$< 2.2.10^{-16}$
Deep breathing	middle thoracic sector	0.81749	$5.395.10^{-13}$
Deep breathing	upper thoracic sector	0.88062	$3.788.10^{-10}$

Based on the acquired significance levels (p-value) in the above table, we can say that we can reject the zero hypothesis with more than 95% reliability. In other words, not a single selection comes from normal distribution. Due to this fact, it is necessary to use the nonparametric Wilcoxon pair test for subsequent testing. We assumed that the average value in the considered area would be the same as in deep breathing. The zero hypothesis can be rejected with more than 99% reliability based on the measured data and the performed test. In other words, values during breathing at rest are statistically significantly lower than in deep breathing, both in the lower thoracic sector and in the areas of moderate thoracic breathing, as well as in the upper thoracic sector.

Discussion

Based on the results, the research cohort does not activate the respiratory sectors at a given percentage. In the examined group of subjects, thoracic respiration prevails, i.e. the involvement of thoracic sectors (both lower and upper chest) above abdominal breathing, both in breathing at rest and deep breathing. The first assumption that TVS students will generate a respiratory wave with corresponding involvement of the respiratory sectors has not been confirmed. We believe that this may be caused by the dysfunction of DSSS related to body posture. Western European civilization uses the typical pattern of posture that originates in the military – legs hyperextended, weight load on the heels, the chest pushed forward, the stomach pulled in, the shoulders pointing backward, which corresponds to the instruction to stick out the chest and pull in the stomach. If we take this position and watch our breathing, we will find that we are not able to breathe freely (Barknowitz, 2004). Similarly, Kolář et al. (2009)

report that we are historically associated with the Sokol view (sports organisation for children and adolescents) of the correct posture, where the shoulder blades are held together, the chest stuck out and the abdomen pulled in. But this is not in line with the ideal posture defined by the central programme. Véle (2012) states that limiting respiratory movements in the lower thoracic sector leads to the destabilisation of the lumbar spine. Consequently, the breathing stereotype changes and chronic hypertonia of the diaphragm and other respiratory muscles develops, with an effect on the whole musculoskeletal system. This is confirmed by the authors Smith, Russell, & Hodges (2009), who published the conclusions of their longitudinal study (7,499 women) showing that the presence or development of incontinence, respiratory problems and gastrointestinal symptoms are associated with the development of back pain and disturbances in the locomotor system. Bradley and Esformes (2014) report that normal breathing plays a key role in the spinal stabilisation and posture. They have shown that diaphragmatic breathing is closely related to functional movement. The second assumption that the values acquired during breathing at rest would be lower than the values in deep breathing was confirmed. Nevertheless, when comparing the percentage of diaphragmatic respiration (lower thoracic sector) in the respiratory wave, it is evident that there is a 10% activity reduction in deep breathing when compared to respiration at rest. Based on this fact, we agree with the statement of Šponar (2003) that most individuals, who do not deliberately work with breathing, cannot use it optimally. This is related to the surplus tension accompanying our lives.

It follows that we should devote much more time and attention to proper breathing in the education programmes, both in school physical education and in sports activities. Exercises focused on proper breathing and correct posture should start at the pre-school age (Sedlářová et al., 2008).

Conclusion

When comparing the percent involvement of the individual chest sectors in the respiratory wave, the activity of the middle and upper chest sections prevails above the lower chest section. The first assumption has not been confirmed. Respiratory values at rest are statistically significantly lower than in deep breathing, both in the lower and middle thoracic area, as well as in the upper thoracic sector. The second assumption has been confirmed. 10% activity limitation occurs during deep breathing in the lower chest sector when compared to the breathing at rest.

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THE ASPECTS OF FOOT DEFECT THERAPY IN CHILDHOOD

Poděbradská Radana
Masaryk University, Brno, Czech Republic, Department of Health Promotion
Rehabilitation Lipová-lázně

Abstract

The treatment of congenital and acquired foot defects in childhood has its specifics, which should be taken into account during the therapeutic considerations, together with the standard aspects of foot defect treatment in adult age. First of all, there is the question of age in which it is possible to diagnose foot defects in children and why, which often collides with the lack of knowledge of developmental ontogenesis of infants through all the fields dealing with this problem. Another aspect, more recent one, is brought about by the quality of the connective tissue, which progresses from generation to generation towards greater laxicity. The change of positioning in the ankle joint brings about a change in the setup of the proximal and distal segments, together with a change in proprioception and afference. Last but not least, there is hypoafferentation and dysafferentation, also caused by changes of lifestyle, whether due to increasing occurrence of overweight and obesity, or due to unsuitable footwear. The ratio of participation of the individual etiological factors in the occurrence of a foot defect then plays a role in the therapeutic consideration. While, for example, the fallen longitudinal foot arch in an infant or a toddler with non-optimal ontogenetic development is usually very well manageable, increased laxicity of the connective tissue appears to be very limiting. It is necessary to approach the small patients in a multidisciplinary attitude, not only in theory, but also in practice, because unsuitably indicated treatment, for example the recommendation of orthopaedic insoles too soon, may aggravate the foot defect.

Key words: *foot defects, psychomotor development, sensorimotor system, physiotherapy*

Introduction

The Quality of Psychomotor Development

The physiological course of psychomotor development represents the essential aspect for the development of physiological foot meeting the requirements of the kinesiological standards. Psychomotor development is genetically determined, automatic, and species-specific (Vojta & Peters, 2010). Within its course and through the process thereof, the anatomical structures are formed and included in the human posture and function. Throughout this development, it is possible to observe the connections in all the structures of the entire body, both anatomic and functional. Correct postural ensuring in the area of the trunk projects itself in the positioning of all the joints of the entire upper and lower limb, forming their postural security for movement, thus limiting the possibilities of isolated functions in the individual joints. On the other hand, if there is a congenital or acquired developmental defect in the area of the foot, the change of positioning within the foot's joints changes the posture of the entire body, especially in chase the child starts to stand up leaning on such foot. However, the optimal positioning in the area of the talus and the development of the foot's positioning preparing for the future support can be observed much earlier in the individual ontogenetic models demonstrated by the child throughout the development (Kolář et al, 2009). During the 4^{th} month of development, the ankle joint achieves for the first time the neutral (central, zero) position between the dorsal and plantar flexion, and at the same time it is possible to observe a neutral position between pronation and supination and abduction and adduction. Such positioning is usually demonstrated by the child as a part of the ontogenetic model of three months of age. Lying on the back, the child is capable of joining the hands in front of the body and putting them in its mouth. During the next weeks, the feet get into mutual contact, first the toes, later the inner edges of feet, and finally also the soles. At this point, the mutual contact of the feet is a necessary part of the development, as it forms a part of the somathesthesic process development – the perception of one's own body and its mapping in the brain. The foot and the hand only get in contact during the seventh month of age. Until then, the child practices the setting of other angles and positions in the area of the ankle joint as a part of other ontogenetic models, i.e. changing the positioning of the neighbouring and distant joints, either in the stepping-forward or the supporting function of the lower limb. Upon achieving the stabilization security in the area of the trunk, the child can use the lower limb to march; a part of this model in the area of the ankle joint, sole and toes being the positioning in the dorsal flexion, pronation and minor abduction with simultaneous metatarsal and toe abduction, or the child can lean on the lower limb. The support initially occurs in the ontogenetic models lying down on a side; a part of the supporting function being the positioning of the ankle joint, the foot and the toes in the dorsal flexion, supination and minor adduction with flexion of the toes. From the sixth month on, when the child is capable of reaching to the sole, it starts to make use of this skill while lying on the side, leaning against the elbow or hand, with the upper leg turned to step forward. This is new information, because despite having the contact with the sole for some time, the child is now in a different position with different postural ensuring.

Prior to actually stepping on the base with the foot, the child starts to crawl on all fours. In this ontogenetic model, the feet gradually relax during the crawling, with the metatarsi copying the base. The relaxation of the feet demonstrates the correct postural ensuring and the ability of relaxation of one movement segment while activating another one. The missing of this function shows a possible incorrect postural ensuring in the area of the trunk and it is not rare. The first standing usually occurs at nine months of age, the standing being of a wide base, and initially it is rather a standing position on the lower limbs with "locked" joints. The stabilization ensuring of the individual joints develops gradually, and the stabilization in the area of the hip joints also improves. In the area of the ankle joints, this change is manifested by the central positioning in the ankle joint, and by the long foot axis directed in front of the body, not to the sides. The change of position brings about the activation of the foot arches, despite the existing fat pad, especially the medial longitudinal arch. Incorrect postural ensuring in the area of the trunk manifests itself by pelvic anteversion. This changed position of the pelvic has impact on the femoral acetabula setting; the femurs are internally rotated and they are not in the medium position in the sagittal plane, but rather in flexion. In the area of the knee joints, the change manifests itself by valgotic positioning of the knees, and there is valgotization in the ankle joints, with a drop of the medial longitudinal and transversal arches. The ranking of pathologies resulting from the simple insufficient postural ensuring is always the same, reflecting in itself the psychomotor development quality.

The instability and changes in the quality of posture may also manifest themselves by standing on the toes. It is normal that the child sometimes stands on the toes after standing up for the first time; mostly because it wants to extend the radius of its grasping capabilities. Nevertheless, once it grabs the toy, it returns back to both feet to achieve a greater stability in manipulation. The ratio of time spent standing on full feet and on the toes should be balanced or preferring the standing on full feet, in order to ensure the correct forming of the foot and the physiological functions of all the anatomic structures of the sole. At this point, it is good to remember that the function forms the organ, and if the child spends a majority of time standing on the toes, the anatomical structures will conform to this situation, especially m. triceps surrae, by functional and later structural shortening. Standing on the toes may also occur unilaterally, often in case there has been an asymmetry occurring during the child's development, for which it is usually included in therapy by Vojta therapy. It may happen that the asymmetrical development is first diagnosed on the basis of standing on one toe in the period of verticalization.

Regarding the area of psychomotor development, it is also good to mention the use of aids designed to improve the comfort of parents, i.e. to engage the child.

The use of a baby walker, when the child is not required to ensure the postural stability of standing, overloading the unprepared structures of the motion system in the vertical position while leaning against the inner edge of the walker with ventral position of pelvis, this having all the functional and possibly structural consequences.

The Quality of Sensorimotor Function

The sensorimotor skill means a coordinated functioning of the sense organs, or their perceptions, more specifically, and of the physical movement in live organisms. The activities and phenomena in which the sense and motoric abilities participate immediately and inseparably are called sensorimotor. By means of touch, skin contact with the surrounding environment, the body gets important information flow necessary for the orientation in space and in our own body (Hermachová, 2001). The sensorimotor function starts to develop as of the moment of birth, via the first contacts on the sole. These are the contacts of the child itself with its sole, and also the contacts with parents, most frequently the mother with the child's sole, and last but not least, it is the contact of the sole with the base. The more high-quality contacts, or perceptions for the central nervous system (CNS), the higher the quality of information outputs to ensure the position and movement. The sole functions as the "reader" of the terrain, and in general, it is true that the more physiological the setting of the sole is in the course of scanning the base, the more complex is the information it reads. And moreover, the higher the quality of the processed output response from CNS, the more precise is the setting of the foot, as a reaction to unstable or uneven terrain with differentiated setting into the smallest motion segment.

The first obstruction in the development of sensorimotor function is represented by clothes, creating a decrease and modification of the sole's contact with the surrounding environment. The second obstruction in the development of sensorimotor function is represented by shoes, which may be indicated as the filter of natural information regarding the quality of the terrain. The third obstruction in the development of sensorimotor function is represented by the terrain itself. During the civilization process, there have been significant changes of the terrain scanned by our foot. From a varied terrain, which was necessary for setting up the initial "software", this information narrowed down to only a few "filtered" materials and a single design – flat surface. Nevertheless, each sense organ needs a wide spectra of information in order to set up its optimal functioning.

This phenomenon is also observed in the cardiovascular system, which needs to mark the period of rest and the period of maximum stress in order to function well, or else it fails easily.

The shoe is designed to protect the foot from damage and to keep it warm in cold weather. It should not, however, limit its function, so it should not be perceived on the foot too much. It should be light and flexible in all the planes (Hermachová, 1998). Nowadays, the shoe manufacturers try to work on these qualities of shoes, but there is a problem with shoes for the smallest children, when it is even more difficult to achieve these qualities on a small surface.

There are a number of methodologies for the sensorimotor function development; the first person to elaborate and present findings on etiology and new options of re-education and prevention of the ankle joint instability being an English orthopedist Freeman. Janda et al. elaborated on Freeman's studies and they developed and published a comprehensive therapeutic approach named "Sensorimotor stimulation methodology", the effectiveness of which has been demonstrated (Pavlů & Novosadová, 2001).

The Quality of Connective Tissues

The so-called ligamentous hyperlaxity may have a negative impact on correct psychomotor development. It is a term that plays a substantial role in the myoskeletal medicine and functional motion system disorders today, but due to the fact that laxity and hyperlaxity of the ligaments can only be diagnosed by palpation, it is usually marked as a subjective, non-measurable perception. The word laxity indicates the opposite of the qualities of physiologically unchanged quality of ligament and its functions. That means the opposite of strength, elasticity and hysteresis of the ligaments. Hysteresis is the memory of flexible medium, remembering the position from which it was stretched and returning back to this position. Due to hyperlaxity, the stability and strength of the individual segments within the motion system cannot be provided for by the ligaments, as it is physiological, but it must be provided for by muscle contraction. Muscle contractions to such extent are not designed to secure stability, and there are requirements for long-term contraction here, the respective muscles are overloaded. There are reflexive changes in these muscles and functional disorders of the motion system with all their properties occur (Poděbradský & Poděbradská, 2009).The change in the quality of connective tissues in children in the course of psychomotor development may limit the postural ensuring.

Natural Movement Activity

The decrease in volume of natural movement activities in children, not only due to attending school, but also due to the decrease in habitual movement activities in general represents quite a significant problem (Craggs, Corder, Sluijs & Griffin, 2011; Basterfield, Adamson, Frary, Parkinson, Pearce & Reilly, 2017). In order to improve the sensorimotor function of the foot, it is necessary that the foot has training, i.e. it is burdened with natural walking, running and voluntary activities in vertical position. The type of movement activities changes together with the decrease in volume of movement activities. While in the past it was natural that children ran and jumped outside, nowadays they prefer sitting down or walking, at most. In some studies, it is apparent that the occurrence of flat foot varies around 22 % in children predominantly sitting at a PC, while the number of such children keeps growing (Stardelova, Conkova, Krtevska, Panovska, Alili & Dzhambazovski, 2013). The results of interventions, the aim of which was to increase the movement activity in children, only show a very little effect for the time being (Biddle, Braithwaite & Pearson, 2014; Metcalf, Henley & Wilkin, 2012).The limits are usually represented by the child's individuality, options of parents and lack of motivation (Atkin, Sluijs, Dollman, Taylor& Stanley, 2016).

Possibilities and Setbacks of Kinesiotherapy

In childhood, the effect of kinesiotherapy mostly unwinds from the adherence of parents to the exercise recommendations. It is best if the parent does the exercise together with the child (Graham, Wall, Larson & Neumark-Sztainer, 2014).

The physiotherapist becomes a lecturer, and the parent becomes a therapist. A number of parents do not accept the role of the therapist, but nevertheless, no child can get better against the will of the parents. The situation is further aggravated by the fact that foot defects usually don't hurt in childhood, and it is difficult to motivate the child to therapy. In order for the therapy to be effective, exercise must be carried out several times a day. It is suitable to adapt the therapy to the child's age, and to select a suitable concept of exercise. The method of choice for children younger than one year is usually Vojta therapy using reflexive locomotion. With older children, this method can usually no longer be applied effectively, until a certain age period. Further on, it is possible to use the Bobath concept, which approaches kinesiotherapy at this age by series of targeted play activities using aids. Once the child accepts the therapeutic role of the parent, it is suitable to include active targeted therapy with a wide scale of concepts and methods (Buchtelová & Vaníková, 2010).

Passive Correction with an Orthopaedic Insole

The opinions of professional public regarding the foot defect solutions, especially the functional etiology, are different. Some doctors believe the defect should be corrected only after the completion of the foot arch development, in their opinion in children older than three years of age (Adamec, 2005). Some use exercise first for the correction, others immediately prescribe passive correction with orthopaedic insoles. The orthopaedic insoles always aggravate the sensorimotor function of the foot, because they act as yet another inflexible layer between the sole and the base. The orthopedic insoles are also limited by the means and possibilities of their use. The children often have only one pair of individually made insoles, which they fail to move from the outdoor shoes into the school slippers, and the effect of passive support is therefore very limited in time. Sometimes it is only the attrition of the orthopedic shoe in specific parts after long-term use that reveals the fact that the child uses the foot in a regular way even in the shoe, because it is not the point to merely fix the foot in the correct position against the base, but it is also important to burden it in this position and to activate it correctly. The shoe is often not enough to achieve this. On the contrary, it is important to point out that suitable utilization of compensation ortheses may attenuate the inner compensation mechanisms of the body, thus preventing the damage of structures participating in such compensation. However, as the development continues and the bone-ligament ratios are modified, the necessity of compensations disappears spontaneously (Vařeka & Vařeková, 2005). The generally recommended ankle boots in the early stages of verticalization are also quite problematic. The ankle joint and movement segments in the area of the sole need to train the stabilization function as well.

Conclusion

The quality of psychomotor development influences the growth and shaping of anatomic structures of the entire body, thus including the sole. If the child fails to go through all the important development milestones in optimal quality, it may result in a changed shape and function of the foot. Both the congenital and acquired foot defects in children must be assessed individually, taking into account the psychomotor development quality, the quality of sensorimotor functions, and the congenital or acquired changes in the quality of connective tissues. When selecting the therapy, it is important to consider the child's age, yet not with respect to the time of starting the therapy, but rather with respect to choosing the right therapy. The functional approach in treatment should be selected at all times, also as a possible preparation for the passive support with an insole or by means of orthopedic shoes, or eventually as a part of complex therapy.

Foot defects, as well as myoskeletal system disorders in children in general deserve great attention, as their prevalence is high and with regard to the current parameters of lifestyle there are many hindrances to changing this situation (Mitova, 2016).

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THE ASSOCIATION OF ACE POLYMORPHISM WITH EXPLOSIVE LEG-MUSCLE POWER IN ELITE VOLLEYBALL PLAYERS

Polakovičová Mája[1], Vavák Miroslav[1], Ollé Róbert[1], Reichwalderová Katarína[2], Mokryšová Stela[2], Slaninová Miroslava[2]

[1] Faculty of Physical Education and Sports, Comenius University in Bratislava, Slovakia

[2] Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia

Abstract

Purpose: The aim of this study was to determine the association of the Angiotensin Converting Enzyme gene variants (*ACE* I/D) with explosive leg-muscle power in elite volleyball players (VOP) and non-athletic controls (CON).

Methods: The study involved 124 participants consisting of elite VOP group, N=61 (males N=31, age 26.5±5.8; females N=30, age 21.8±4.3) and CON group, N=63 (males N=32, age 20.8±0.9; females N=31, age 20.1±0.9). Genotyping for *ACE* I/D was performed using a polymerase chain reaction on DNA extracted from buccal swabs. The leg-muscle power performance was assessed by means of a vertical jump (VJ) test. The distribution of *ACE* I/D genotype between the groups was identified by Chi-Square and Fisher's exact tests. Association between genotype and VJ performance was tested using two-way ANOVA at $p < 0.05$. Analyses were performed separately in males and females because gender-specific influences of *ACE* polymorphism on phenotypic traits were observed.

Results: Genotype distribution of all control and athletic groups met the Hardy–Weinberg equilibrium (all $p > 0.05$). Genotype distribution did not differ significantly between groups (VOP: 34.4% (DD), 45.9% (ID) and 19.7% (II); CON: 25.4% (DD), 61.9% (ID) and 12.7% (II); $p=0.179$), even when analysis was carried out separately between males and females. Considering the results for athletic and non-athletic groups, VJ performance was significantly better in the VOP compared to the CON, in both, males ($p < 0.001$) and females ($p < 0.001$). According to the *ACE* I/D polymorphism, two-way Anova did not observe any effect of genotype on VJ performance in males. However, the genotype by group interaction ($p=0.04$) was detected in females. Female VOP with DD genotype have a higher VJ performance than ID and II carriers. No association between *ACE* I/D genotype and VJ performance was observed in non-athletic females.

Conclusion: Our study showed no differences in *ACE* genotype distribution in the elite VOP compared to the CON group. The D allele of *ACE* gene is usually associated with a higher proportion of fast, glycolytic muscle fibers and could favour power

oriented performance. We have found gender-specific association of DD genotype with explosive leg-muscle power in female elite VOP. Results need to be confirmed in a larger sample.

***Key words**: ACE I/D polymorphism, volleyball, vertical jump*

Introduction

Athletic performance is influenced by both genetic and environmental factors. Environmental factors such as training, nutrition and skill have long been considered as crucial to the develpment of athlete`s physiological potential. The genetic factors responsible for the anthropometric, cardiovascular and muscular characteristics important the training adaptation have been identified several decades ago. Pivotal population study (Bouchard, 2012) of more than 37 000 pairs of fraternal and identical twins from six European countries and Australia have shown that heredity determines at least half the variation in the response to training. Up to now more than 200 genetic markers have been linked to the elite athlete status (Ahmetov et al, 2016). One of the most frequently investigated genetic markers in the relation to athletic performance is the angiotensin converting enzyme gene (*ACE*) I/D polymorphism (Puthucheary et al, 2011). Variants in this gene have been associated with the elite athletic status and with the physical performance in general, even the associations are sometines conflicting (Rankinen et al, 2000).

ACE is one of the key components of the renin angiotensin system and the kallikrein-kinin system, both of which are involved in the regulation of blood pressure and vascularization. Moreover, the *ACE* is expressed also in skeletal muscles, where it influences the proportion of fast, glycolytic, type 2X muscle fibers and metabolic processes (Zhang et al, 2003). The human *ACE* gene is located on chromosome 17 in position 17q23.3 with a restriction fragment length polymorphism consisting of the insertion (I) or deletion (D) of a 287 base pair Alu repeat sequence in intron 16 (Bernestein et al, 2013). Three variants of *ACE* genotypes include DD, II homozygotes, and ID heterozygotes.

Studies investigating the links between the *ACE* genotype and athletic performance have shown that the I allele is associated with lower ACE activity in both serum and tissue and improve performance in endurance sports (Myerson et al, 1999; Williams et al, 2000). Whilst the D allele is associated with the higher concentration and activity of ACE that leads to an enhanced performance at sports requiring strength or short spurt of power. Some of the studies support the concept that the DD genotype may be associated with a greater proportion of fast-twitch fibers which could explain the possible influence of the ACE D-allele upon strength and power, particularly at high velocity tasks (Costa et al, 2009; Thompson et al, 2006). However, not all studies have shown correlation between the *ACE* I/D polymorphism and enhanced physical performance (Rankinen et al, 2000; Zoossmann-Diskin, 2008).

The most of the *ACE* I/D association studies observed the sport disciplines where endurance or power plays a key role, like track & field athletes, cyclists or swimmers. The studies observing the influence of *ACE* (I/D) gene in team sports are less reported and results are more inconclusive (Orysiak et al, 2017). Volleyball, as one of the most popular sport game includes fast movements, jumping and sudden shifts which need high power and strength for optimized performance. Muscle power can be measured using different testing methods and in different upper or lower extremity muscle groups. The vertical jump tests are widely used for the assessment of explosive strength of lower limbs. Vertical jumping performance can be assessed using a variety of tools and types of jumps (Sattler et al, 2012). In our study the 10 second repeated jump test was performed to estimate VJ performance (Poderys et al, 2015). Based on the previous findings on elite athletes we suggested that D allele could be beneficial in power performance and we hypothesized that the *ACE* I/D polymorphism is associated with vertical jump performance. The main purpose of the present study was to examine the distribution of ACE genotype and the association between *ACE* I/D polymorphism and the ability to produce peak muscle power estimated as vertical jump height (VJH) in elite volleyball players in Slovakia.

Methods

Participants

The study involved 124 participants consisting of elite VOP group, N=61 (males N=31, age 26.5±5.8; females N=30, age 21.8±4.3) and CON group, N=63 (males N=32, age 20.8±0.9; females N=31, age 20.1±0.9). A group of 61 elite athletes were members of volleyball teams who participated in international competitions and major Sloval Leagues. Written consent was obtained from each subject. The study protocol was approved by the institutional ethics committee, and was in accordance with the Declaration of Helsinki for Human Research.

Vertical jump performance

We assessed the vertical jump height test using an easily portable device FiTRO Jumper contact jump mat (FiTRONiC Diagnostic and Training Systems LTD, Bratislava, Slovakia) to evaluate explosive leg-muscle power (Tkáč et al, 1990). The system consists of contact switch mats connected to the PC and measures the contact and flight times with which the basic biomechanical parameters of serial jumps are calculated. The subjects performed a 10 seconds repeated vertical jump test. The starting position was straddle standing with hands on hips in order to minimize the influence of the arms on the jump. After the initial hop, a 10 seconds repeated jump test was performed. During the jump, the trunk must remain "as vertical as possible" to limit its influence on the performance and with the knees "as straight as possible" during the contact and flight phase (knee angle around 180 degrees, foot is in extension). The subjects performed 2 trials of 10 second repeated jump tests. Rest intervals between trials were approximately 60 seconds. The average height and average contact time of the three best attempts were taken into account for further analysis. Before the testing, all the participants received instructions on the test, after which a familiarizational session was accomplished. All the tests were performed during 2017 under the supervision of the same researcher. The reliability of the VJH measurement was examined using coefficient of variation CV = 6.2% and intra-class correlation coefficient of R = 0.93.

Genotyping

Genomic DNA was extracted from buccal swabs using cotton stick and standard protocol with Chelex (Bio-Rad). The samples were incubated in 5% Chelex solution for 30 min at 56°C and vortexed for 15 s. After extraction, samples were placed to NucleoSpin forensic filters (Macherey Nagel) and spun for 3 min at high speed in microcentrifuge. Concentration of DNA in solution was measured by Nanophotometer (Implen Version 2.1.) and also visualised on 1% agarose gel. Genotypes were determined using PCR with primers: forward, CTGGAGACCACTCCCATCCTTTCT; reverse, GATGTGGCCATCACATTCGTCAGA PCR was performed in thermocycler (Biometra). The thermal-time PCR was done as follows: initial denaturation for 8 min at 95 °C, and 30 cycles with denaturation for 1 min at 95 °C, annealing for 45 s at 58 °C and extension for 45 s at 72 °C, and final extension at 72 °C for 10 min. The specificity of the fragments was verified by sequencing. Samples of heterozygotes and ambiguous samples were repeated several times. In all PCR reactions, a negative control without DNA was used to prevent contamination. The amplification products were visualized on 2% agarose gels stained with ethidium bromide. The sizes were 490 bp for I allele and 190 bp for D allele. Genotypes II and DD had one band of correspondent size and genotype ID had two bands.

Statistical Analysis

Standard statistical methods were used for the calculation of means and standard deviations (SD) for quantitative variables. Data distribution was tested with the Kolmogorov-Smirnov test. Levene's test was used for checking of homogeneity of variance. Differences in the distributions of the *ACE* genotypes and Hardy-Weinberg equilibrium assumption were examined using Chi-square test and Fisher exact test.

The two-way ANOVA (3 × 2 factorial design) was used to analyze the relationship between *ACE* I/D polymorphism (DD, ID, II) in two gropus (VOL and CON) and VJH separately in males and females. If a statistical difference was present, a Tukey's post hoc test was performed to detect the inter-group differences. The p values of ≤ 0.05 were set as statistically significant. Statistical analyses were performed using SPSS 12.0 software (SPSS, Chicago, IL) and Microsoft Excel 2000 (Microsoft, Redmond, WA).

Results

Characteristics of the volleyball players and non-athletic controls separated by gender are shown in Table 1. Male VOP were older ($p < 0.05$) than male in control group and all females. In both genders the VOP were heavier and taller than CON ($p < 0.001$). Likewise, VOP showed better jumping performances than CON ($p < 0.001$) in both genders.

Table 1. Characteristics of study participants by gender and group

	Volleyball players		Controls	
	Males (N=31)	Females (N=30)	Males (N=32)	Females (N=31)
Age	$26.5 \pm 5.8^{*\wedge}$	21.8 ± 4.3	20.8 ± 1.1	20.1 ± 0.9
Weight [kg]	$89.2 \pm 7.7^{*\#}$	$70.3 \pm 7.9^{\#}$	$79.5 \pm 9.4^{*}$	56.1 ± 6.9
Height [cm]	$195.1 \pm 6.2^{*\#}$	$180.8 \pm 6.4^{\#}$	$183.3 \pm 7.7^{*}$	164.1 ± 5.9
BMI [kg/m^2]	23.4 ± 1.5	21.5 ± 1.7	23.6 ± 3.6	20.8 ± 1.8
VJH [cm]	$37.1 \pm 7.8^{*\#}$	$29.6 \pm 4.2^{\#}$	$25.7 \pm 4.1^{*}$	21.6 ± 4.5

Legend: $^{*}p < 0.05$*, males different from females;* $^{\#}p < 0.001$, $^{\wedge}p < 0.05$*, VOP different from CON*

Genotype distribution of all control and athletic groups met the Hardy–Weinberg equilibrium (all $p > 0.05$). Genotype distribution (Fig. 1) did not differ significantly between the groups ($p = 0.179$), even when analysis was carried out separately between males and females.

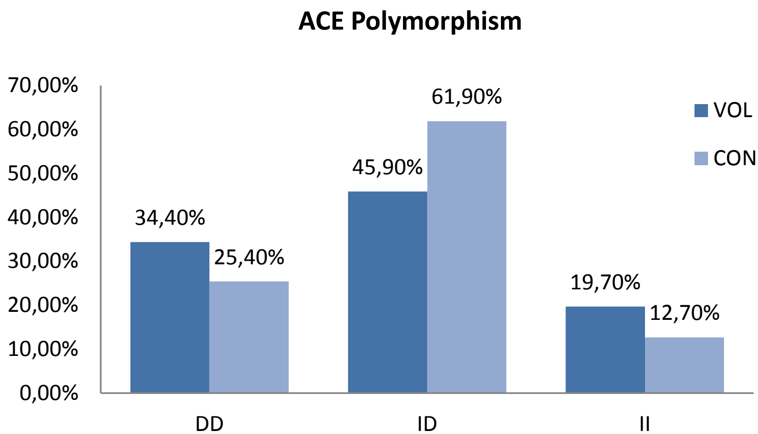

Figure 1. Comparison of ACE I/D genotype frequencies (%) between the elite volleybal players and the non-athletic controls.

Considering the results for athletic and non-athletic groups, VJ performance was significantly better in the VOP compared to the CON, in both, males ($F = 21.2$, $p < 0.001$) and females ($F = 55.9$, $p < 0.001$).

The association between the *ACE* I/D polymorphism and VJH within each group is presented in Table 2. Male and female athletes were analyzed separately given the known gender-specific influences of the *ACE* genotype on phenotypic traits (Min et al, (2009).

Table 2. Means ± SD of VJH by ACE I/D genotype in volleyball players and control groups

	ACE I/D	VJH [cm]	
		Volleyball players	Controls
Males	DD	38.0 ± 7.4	26.8 ± 5.1
	ID	37.2 ± 8.5	26.2 ± 4.4
	II	36.5 ± 7.1	24.0 ± 3.3
Females	DD	31.3 ± 2.2*	20.1 ± 4.8
	ID	28.2 ± 3.0	21.9 ± 3.5
	II	26.3 ± 2.1	23.0 ± 2.9

*Legend: * $p < 0.05$, difference of DD genotype compared to II genotype in post hoc test*

The two-way ANOVA did not observe any effect of genotype on VJH in males (F = 0.21, $p = 0.817$). However, the genotype by group interaction (F = 2.8, $p = 0.04$) was detected in females. Female VOP with DD genotype have a higher VJ performance than ID and II (< 0.05) carriers. No association between *ACE* I/D genotype and VJ performance was observed in non-athletic females.

Discussion

In order to examine the effect of the *ACE* I/D polymorphism on the leg muscle explosive power performance we studied the association of the *ACE* I/D polymorphism in group of male and female elite volleyball players and in group of non-athletic adults.

Recent findings from association studies are contradictory. Whereas several studies showed no effect of the *ACE* I/D polymorphism on muscular strength and power phenotypes (Pescatello et al, 2006), others reported an advantageous effect of the D allele for power performance (Folland et al, 2000; Woods et al, 2001).

All studied groups, VOP and CON as a whole as well as gender separated met the Hardy-Weinberg equilibrium assumption. The genotype distribution of *ACE* (I/D) did not differ significantly between VOL and CON. We found only slightly higher prevalence of the DD genotype in VOL compared to CON, both in males and females, although the level of statistical significance was not reached. The lack of association between *ACE* I/D polymorphism and the team-sports performance could be due to the mixed nature of these sports, in which both the aerobic and anaerobic energetic systems are important for successful performance (Orysiak et al, 2017). Besides, it is important to note that one gene alone is not able to explain the entire variability of the performance (Webborn et al, 2015), especially in team-sports.

The two-way ANOVA was performed to investigate the influence of *ACE* I/D polymorphism to the explosive leg-muscle power evaluated through VJH measurement. Variation within the *ACE* gene was significantly associated with VJ performance only in female volleyball players, but not in female non-athletes. The analysis did not confirm this association in males, either in VOL, nor in CON group. Our outcome supports the results of other authors who revealed that the effect of the *ACE* genotype was different for male and female athletes (Min et al, 2009; Costa et al, 2009). Renin-angiotensin system in muscle tissue was proven to be markedly affected by gender by means of down-regulation of angiotensin receptor by estrogen (Fischer et al, 2002). The gender specific association of *ACE* I/D polymorphism with the VJH in female athletes only could be explained by epigenetic and environmental factors or their complex interactions that could not be present in non-athletic females.

Concerning the role of ACE polymorphism in volleyball sport, this study demonstrates that the homozygous genotype DD was associated with better VJ performance in female volleyball players. This association could be exploited to identify those athletes that could better perform in specific positions involving higher demands on jumping performance. However, our results should be taken with caution due to the relatively low number of participants and further studies are required.

Conclusion

Our study showed no differences in *ACE* genotype distribution in the elite VOP compared to the CON group. The D allele of *ACE* gene is usually associated with a higher proportion of fast, glycolytic muscle fibers and could favour power oriented performance. We have found gender-specific association of DD genotype with explosive leg-muscle power in female elite VOP. Results need to be confirmed in a larger sample.

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PONSETI METHOD OF TREATMENT OF CLUBFOOT (CONGENITAL TALIPES EQUINOVARUS) VOJTA THERAPY AS A PART OF TREATMENT

Psotka Libor[1], Poděbradská Radana[2,3]
[1]Ortopedické oddělení nemocnice Šumperk
[2]Fakulta sportovních studií, Katedra podpory zdraví, Masarykova Univerzita v Brně
[3]Rehabilitace Lipová-lázně

Abstract

The Ponseti method is based on a redress therapy by means of series of passive exercise with attaching plaster fixations to the affected lower limb. Percutaneous tenotomy of the Achilles tendon with subsequent plaster fixation lasting 3 weeks forms a part of therapy using this method in most of the children treated this way. Subsequently, a Denis-Browne splint is worn until the child is 3-4 years old. The Ponseti protocol may eventually include the transposition of tibialis anterior muscle, if the dynamic supination of the forefoot persists. We believe that rehabilitation therapy as an ancillary method to influence the foot development, and also as a method of prevention to capture and treat the disorders of the child's psychomotor development, represents an inseparable part of the child's treatment. Vojta therapy with use of reflex locomotion, eventually using tapes, represents the method of choice. In this way, it was possible to influence correct development of foot in going through the standard Ponseti treatment protocol and to prevent the reoccurrence of the defect even in removing the Denis-Browne splint earlier than the Ponseti protocol recommends. Two case studies have been presented as to the reaction of the motion system to the unilateral tenotomy of Achilles tendon as the possible risk of the child's asymmetric development, and further on the individual approach to the general recommendations regarding the application of Denis-Browne splints.

Key words: *Ponseti method, talipes equinovarus, Vojta therapy, physiotherapy, asymmetry in development*

Introduction

The Ponseti method is currently the preferred method of treatment of a congenital disorder named clubfoot (congenital talipes equinovarus) (Dunkley, Gelfer, Jackson, Parnell, Armstong, Rafter & Eastwood, 2015). The method was developed by Dr. Ignatio Ponseti in Italy during the 1960s. In the Czech Republic, it was accepted and established as a treatment method after the Congress of the European Paediatric Orthopaedic Society in 2005. The therapy should start as soon as possible after the child is born, but treatment is possible up to two years of age, even in case of the initial unsuccessful non-invasive treatment (Morcuende, Dolan, Dietz & Ponseti, 2004). The Ponseti method is based on a redress therapy by means of series of passive exercise of the affected foot with attaching plaster fixations onto the lower limb within one-week intervals as a standard. The so-called "accelerated Ponseti protocol" has also been described, in which the one-week intervals are reduced to five-day intervals (Morcuende, Abbasi, Dolan & Ponseti, 2005). The "Ponseti protocol" brings about the correction of the abnormal relations between the tarsal bones, but moreover, it also corrects the abnormal shapes of the individual tarsal bones, probably due to changes in the mechanical burden of the fast growing tissues (Pirani, Zeznik & Hodges, 2001). In most children, the therapy includes the percutaneous tenotomy of Achilles tendon with subsequent plaster fixation lasting 3 weeks. After that, Denis-Browne splint is applied and worn up to the age of 3-4 years. According to the effect of treatment, percutaneous tenotomy may be repeated before the child is 2 years old. Also included in the Ponseti protocol, there is the eventual transposition of tibialis anterior muscle, if the dynamic supination of the forefoot persists. This operation is recommended for children older than 3 years of age. Children not responding to the Ponseti therapy must undergo classic surgery according to McKay.

In our opinion, physiotherapy forms a suitable part of the complex care for a child with this congenital deformity, as an ancillary method to influence the foot development, and also as a preventive method to capture and treat the psychomotor development disorders in a child. At this age, Vojta therapy is the method of choice. Vojta's technique allows for the entry into the genetically coded movement programme of a human being, into its management, and a precise motor response can be invoked by an accurate intervention from the periphery (Kolář et al, 2009). The treatment using reflexive locomotion offers the chance to prevent the development of infantile cerebral palsy and its fixation. Besides the paediatrics, reflexive locomotion also has its significance in orthopaedics and surgery. Using reflexive locomotion greatly decreases the indications to surgery in patients with orthopaedic defects (Vojta & Peters, 2010).We tried to influence the correct development of foot by means of Vojta therapy in going through standard Ponseti treatment protocol, and to prevent the reoccurrence of the defect even in case the Denis-Browne splint is removed earlier than recommended by the Ponseti protocol. Dunkley et al. (2015) also describe a successful cooperation between a physiotherapist and an orthopaedist, but without using Vojta therapy. Another method used was the kinesiotaping to correct the position of toes owing to the utilization of the Denis-Browne splint (Fig. 1 and 2). In the course of current physiotherapy and the Ponseti method, there were two cases of asymmetric body posture in children following the tenotomy of Achilles tendon at an age when the asymmetric body posture is no longer physiological. The infants showed no pathological asymmetric body posture prior to the surgery and they were not subject to any potential influences, which might possibly induce the asymmetry, besides the tenotomy. These case studies are presented below. There are important milestones in the psychomotor development of a child, the so-called ontogenetic models, which the child should go through in order to form the postural system correctly. In this concept of development evaluation, the physiological asymmetry is described, but it has its own rules as to quality and quantity, especially due to the fact that the quality of the lower movement pattern shown by the child in development is fully contained in the quality of the higher movement pattern with all the eventual deviations. Taking care of the scar, which must be treated and loosened layer after layer, represents an inseparable part of the rehabilitation care. An untreated scar may cause functional and later structural changes of the movement system (Lewit & Olsanska, 2005).

Case study No. 1

A prematurely born boy, at the calendar age of 5 weeks, who was born via Caesarean section. The premature delivery occurred on the basis of spontaneously initiated womb contractions. Post-delivery adaptation was fine, with Apgar score 10--10-10 and vital statistics 2490 g, 44 cm.

Dg. congenital talipes equinovarus, both-sided, stiff/soft

From the third day after birth there were repeated applications of plaster fixation, 5-times in total, always for a period of one week with one-week pauses. Tenotomywas not indicated in the early stages of the therapy. Denis-Browne splint was prescribed later, at the age of 2.5 months. At the age of four weeks, an orthopaedist prescribed psychomotor development examination after an orthopaedic examination for non-optimal posture, evaluated by the orthopaedist. A complex kinesiology analysis was carried out, based on which the child was not indicated for Vojta therapy; regarding physiotherapy, the child was only monitored. The evaluation was concluded with finding non-optimal inclusion of the abdominal muscles in the postural function, currently within a wider standard. A regular development check was scheduled at the calendar age of 11 weeks, with the age decisive for the evaluation of development being 7 weeks, corrected after subtracting the premature period. From the point of view of development, the main problem seems to be the non-optimal activation of ventral muscle chains with the main clinical manifestation in lying on the stomach, when the child shows no support on the forearms, corresponding to the age, and in lying on the back, when the child cannot assume rest position and is unstable. The child shows no signs of asymmetry in development. Vojta therapy was initiated. During the therapy, the development deviations are gradually corrected. The correction of flexed posture of the 4th and 5th toe on the left leg with a tape was carried out as a part of the physiotherapy. The flexed posture of toes occurred due to the non-optimal position of the foot in the shoes of the correction splint.

Figure 1 and 2. Flexed toes and correction with a tape (Case study No. 1)

The tenotomy of the Achilles tendon on the right was indicated and carried out at the calendar age of 3.5 months. It was not indicated on the left side. On the day of the surgery and for a period of one week afterwards, the child is without Vojta therapy. A check-up scheduled one week after the tenotomy discovered marked asymmetry of trunk with a convex curve to the right. According to the parents, the asymmetry occurred after the surgery and this posture persists.

Figure 3. Asymmetry when lying on the back, age: 15 weeks (Case study No. 1)

Vojta therapy continues. Asymmetries still occur in the course of the ontogenetic models of psychomotor development. The achieved models are only preferred to the left side. Sleeping is still preferred in the position lying on the left side with lordosis of the entire trunk and extension of head, which occurred after the tenotomy.
At the calendar age of 9 months, the child starts coordinated crawling on all fours. The presumption of physiological development includes the gradual improvement of quality in the achieved ontogenetic model due to its practicing and automation. The mother no longer manages to keep the child in exercising position. Vojta therapy is therefore discontinued. The next check-up is scheduled for the calendar age of 10 and a half months; there are significant quality deviations of the motion system in the coordinated crawling. The child holds the crura and feet above the base in a fixed position: there is hyperabduction in the hip joints, 100-110° flexion in the knee joints, ankle joints are in medial position, feet are in abduction. Stepping-forward of the lower limb is missing during the crawling, and it is replaced with pelvic elevation and lumbar and thoracic spine lateroflexion. In this situation, the child achieved a new ontogenetic model – standing up for the first time, while in the psychomotor

development, each lower ontogenetic model is fully integrated in the higher model. Standing is wide-based with non-optimal participation of abdominal muscles, the hip joints are in the position of external rotation, knee joints are in hyperextension, and the feet are in abduction. Based on the therapeutic judgement, re-initiation of Vojta therapy is recommended again, trying to find a possible compensation for the constitutional disproportion between a robust child and subtle mother. The condition is further consulted with the attending orthopaedist with a proposal to remove the Denis-Browne splint, which not only influences the position of the foot in the ankle joints, but also of all the other joints of the lower limbs, as well as the axial system. Exercise using Vojta therapy would currently probably fail to compensate for the passive night attachments of splint, which now supports the deviations in the child's motion system. The splints were removed.

An orthopaedic check-up after one month of Vojta therapy showed satisfactory state; the range of motion and posture in the area of the right foot are without changes, even without the splints, and the level of quality and quantity assessment of the right foot is. Regarding the development, the quality of crawling on all fours improved significantly, with better trunk stabilization and differentiation of movement of the lower limbs while crawling. Standing up is based less widely with a better position of axes of all the lower limb joints. The child is 12 months old and Vojta therapy still continues.

Case study No. 2

The girl was born in due time, via spontaneous delivery using forceps due to perinatal complications. She was resuscitated by several inhalations by means of manual resuscitator. Apgar score was 6-8-10, with vital statistics 3800 g 52 cm, and post-delivery adaptation was fine.

Dg. congenital talipes equinovarus, right-sided, stiff/soft

The therapy was initiated on the day of birth by means of a redress plaster splint. Further on, tenotomy of the Achilles tendon was indicated and planned. Frejka abduction pillow was prescribed due to non-optimal development of hip joints, IB on the right, IIC on the left. The prosthetic aid to correct the hip joint development was changed to Pavlík harness after a screening check-up of hip joints at the age of 6 weeks. The orthopaedist then sent the girl for examination due to non-optimal body posture. At the calendar age of 4 weeks, based on a complex kinesiology assessment, there were only wider-standard deviations in terms of non-optimal participation of abdominal muscles. The child remained to be monitored. There is a check-up kinesiology examination at the calendar age of 9 weeks. At this point, the non-stable position of the child lying on the back with the non-optimal participation of ventral muscle chains and with preferring the right side, seems to be the main problem limiting the correct psychomotor development. Vojta therapy was initiated. The quality of the ontogenetic models achieved improves gradually; at the age of three months, there is no asymmetry in the child's development. At the age of 3.5 months, the tenotomy of the Achilles tendon on the right was carried out. On the surgery day and a week afterwards, the child does not exercise Vojta therapy. Following the tenotomy, there is asymmetry in the area of the trunk, with the trunk being shifted convexly to the right, and there is significant instability in the position lying on the stomach with a fixed position of the arms. The right arm is stretched forward with elbow extension and with a fist; the left arm is relaxed, the child falls back to the position lying on the back over the right side. Vojta therapy was reinitiated.

Figure 4 and 5. Asymmetry in the position on the back and on the stomach, age: 15 weeks (Case study No. 2)

Development parameters continue to improve gradually, Vojta therapy is no longer indicated at the age of 6 months. There is no asymmetry. Therapy with Pavlík harness was terminated during an orthopaedic check-up. The therapy with Denis-Browne splint continues. At the age of 7 months, the child shows ontogenetic models corresponding to the age with no deviations from quality, demonstrating both-sided diagonal sitting position. The child assumes somologous position on the knees. Denis-Browne splint is applied at nights. Psychomotor development continues to be monitored.

Discussion

The aim of treating the congenital development defect of the talipes equinovarus type foot should always be to achieve a functional, flexible, non-painful foot, which no longer needs correction by means of specially adapted shoes (Miller, Carry, Mark, Engelman, Georgopoulos & Dobbs, 2016). The Ponseti method significantly reduced the need for and the scope of surgical and orthopaedic interventions in the therapy of this congenital foot defect (Morcuende, Dolan, Dietz & Ponseti, 2004). Nevertheless, such intervention may bring about other risks for the immature motion system, even if less significant, which should be taken into consideration. From the point of view of physiotherapy, it is possible to evaluate the quality and quantity of the child's psychomotor development, from which it is possible to predict the motion system's auto-repair abilities and the level of burden of the selected therapy. It is a fact that a child with good quality of motion system management will react to asymmetry differently than a child that already starts the therapy with asymmetry. In the described case studies, the child was also examined by the physiotherapist during the therapy with plaster before tenotomy, and despite this, the child did not respond to this type and stage of treatment by asymmetric body posture.

The described case studies show a possible asymmetry risks for a developing child. A congenital defect that would later prevent the child from walking is naturally a more significant problem within the context and priorities of development, but nevertheless, asymmetry also brings about future risks, e.g. the risk of scoliosis of asymmetric defective body posture. This is namely due to the fact that each lower development model is fully composed in the higher development model, including the eventual asymmetries. An examination and monitoring by a physiotherapist represents a suitable addition to the Ponseti treatment method. Some studies mention the participation of a physiotherapist in the treatment, but within the framework of manipulation with the foot and training the parents, which is carried out by an orthopaedist in our region (Shack & Eastwood, 2006). A physiotherapist may also predict the level of impact on the child's development in regular utilization of Denis-Browne splint, and also recommend to the orthopaedist a modification in the frequency of its use in the course of significant development milestones.

Conclusion

In order to confirm the risk of developing asymmetries in a child during the Ponseti therapy, specifically upon the tenotomy of the Achilles tendons, it is a good idea to elaborate further targeted studies with a greater number of treated children. The case studies show further options of cooperation between the physiotherapist and the orthopaedist in correcting the congenital foot defect, also showing some further aspects of their therapy.

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ULTRASOUND DIAGNOSTICS OF LATERAL ANKLE INSTABILITY

Řezaninová Jana, Hrazdira Luboš, Struhár Ivan, Moc Králová Dagmar
Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czechia

Abstract

Ankle injuries involving the lateral ankle ligaments are among the most common injuries of the musculoskeletal system. Ankle ligament injuries are collectively known as ankle sprains, which refer to the mechanism of the injury rather than the degree of the injury. Diagnostic accuracy of complete lateral ligaments rupture with an acute instability of the ankle joint (grade III) and ligaments laxity in adults with the chronic ankle instability is problematic. Stress ultrasonography can image the lateral talocrural joint and evaluate acute or chronic lateral ankle instability.

Purpose: The aim of this study was to investigate the result of ultrasound diagnostics of lateral ankle instability in held-forced positions (anterior drawer test).

Methods: Total of 40 patient were examined. 20 patients were examined after acute lateral ankle sprain (grade III) under local anesthesia. 20 patients were examined with chronic ankle instability symptoms. Diagnosis of acute ankle instability and chronic mechanical ankle instability was based on musculoskeletal ultrasound examinations. The distance between the posterior rim of the tibia and talus was measured for each ankle. To diagnose the ligament tear as being a complete tear, the difference between the injured and uninjured ankle had to be greater than 3 mm in dorsal cuts (Ernst approach to identify talocrural instability).

Results: Ultrasound examinations performed under local anesthesia with ankles in held-forced positions (anterior drawer test) demonstrated that the difference between the injured and uninjured ankle was greater than 3 mm in dorsal cuts. We found no significant differences in talocrural joint laxity between acute and chronic ankle instability.

Conclusion: Stress ultrasonography in acute and chronic ankle instability identified significant differences in non-stress (basic neutral position) and stress position (anterior drawer test). Incomplete healing of the ligament tissue results in post-traumatic ligament laxity, predisposing the joint to further injury. Ultrasound imaging represents an effective, non-invasive and relatively low-cost method without negative side effects, which makes the ultrasound scanner a practical tool in the clinical setting.

Key words: *lateral ankle instability, post-traumatic talocrural joint laxity, stress ultrasonography, anterior drawer test*

Introduction

Ankle sprains are among the most common sporting injuries (Hossain & Thomas, 2014; Renström & Konradsen, 1997). Although most of these patients get better with conservative treatment, a significant number continue to have long term problems with pain, swelling and chronic ankle instability (Hossain & Thomas, 2014). The stability of the ankle depends on its passive bony and ligamentous suports and its muscular (peroneals and posterior tibial muscle) active support). The lateral ligamentous complex, which consists of the anterior talofibular (ATFL), the calcaneofibular (CFL), and the posterior talofibular (PTFL) ligaments, is most commonly injured (Del Buono, Aweid, Coco & Maffulli, 2013).

The most common mechanism causing lateral ligament injuries is a situation where the ankle goes into a combination of plantar flexion and inversion (Renström & Konradsen, 1997; Maffuli, Longo, Petrillo & Denado, 2012).

Ankle sprains are classified into three grades. In grade I, the ligament is stretched without tearing; there is no laxity, little swelling or pain, and the mechanical function is hardly affected. In grade II, the ligament is partially torn and has minimal laxity with moderate swelling and pain. In grade III, there is complete rupture of the ligament with acute instability of the joint, severe swelling, hemorrhage, and loss of function and mobility of the ankle (Cass & Morrey, 1984). Severity of secondary changes (e.g. swelling, hemorrhage), however, often does not correspond to the grade of injury.

The ATFL tears first followed by rupture of the anterolateral capsule. With further inversion, the CFL will be ruptured followed by variable injury to the PTFL and the anterior part of the deltoid ligments (Renström & Konradsen, 1997).

Incomplete healing of the ligament tissue results in ligament laxity, predisposing the joint to further injury and chronic ankle instability. Chronic ankle instability can be subdivided into functional and mechanical instability.

Functional instability is the chronic disability after an ankle inversion injury that can be attributed to lateral ankle ligament deficiency and is characterized by "giving way" problems. The patient with functional ankle instability usually describes a subjective feeling of the ankle giving way, pain and swelling. Known factors include mechanically insufficient ligaments, peroneal muscle weakness and proprioceptive deficit (Renström & Konradsen, 1997). Freeman, Dean and Hanham (1965) suggested that functional instability was due to motor incoordination secondary proprioceptive disorders.

Mechanical instability is characterized by ankle mobility beyond the physiological range of motion, which is identified on the basic of a positive anterior drawer test or talar tilt test, or both (Renström & Konradsen, 1997). The anterior drawer test measures the amount of damage to the ATFL, according to the anterior translation of the talus with respect to the tibia. An increased translation indicates incompetence of the ATFL (Del Buono, Aweid, Coco, & Maffulli, 2013).

Various diagnostic procedures have been used to determine and assess ankle instability (ultrasonography, radiography, magnetic resonance imaging). Ultrasonography has been shown to be a useful diagnostic modality for ankle injuries given the superficial nature of the ankle soft tissues and the ability to perform dynamic stress tests (e.g., anterior drawer test, talar tilt test) (Khoury, 2007; Maffuli, Longo, Petrillo & Denado, 2012).

Ultrasound dynamic stress tests represent a non-invasive and relatively low-cost method without negative side effects, which makes the ultrasound scanner a practical tool in the clinical setting. This technique may be used to differentiate complete and incomplete acute tears of ATFL (Campbell, Menz & Isaacs, 1994).

Traditionally it is used by specialists in traumatology, orthopaedics, radiology and also in the physiotherapy.

Correct diagnosis, treatment and rehabilitation of the ankle inversion injury are important to prevent both the persistence of symptoms and the development of chronic ankle instability. Symptomatic chronic ankle instability is develop in as many as 20 % of patients after the inversion ankle injury (Del Buono, Aweid, Coco, & Maffulli, 2013).

The aim of this study was to investigate the result of ultrasound diagnostics of lateral ankle instability in held-forced positions (dynamic stress tests – anterior drawer test).

Materials and Methods

This prospective study was conducted of 40 patients who experienced acute lateral ankle instability or chronic mechanic ankle instability between 2016 and 2017. All of 40 subjects signed an informed consent before being enrolled in the study.

Twenty athletes whose symptoms indicated potential grade III ankle lateral ligament injury with acute ankle instability and twenty athletes whose symptoms indicated mechanical chronic ankle instability were physically examined by a senior sports orthopedic surgeon.

Basic characteristics of patients are shown in Table 1.

Table 1. Basic characteristics of participants.

	Sex	Mean Age±SD (years)	Mean Height±SD (cm)	Mean Weight±SD (kg)
Acute ankle instability	Men (n = 10)	29.0 ± 5.3	184.5 ± 6.7	83.7 ± 8.3
	Women (n = 10)	24.6 ± 6.5	163.4 ± 7.9	60.2 ± 9.6
Chronic ankle instability	Men (n = 10)	32.2 ± 6.2	186.7 ± 5.9	85.3 ± 7.8
	Women (n = 10)	26.3 ± 7.1	165.3 ± 8.1	58.4 ± 8.4

SD, standard deviation

After clinical examination (within 48 hours after the injury in patients with acute instability) ultrasonography was used to examine the injured and uninjured (contralateral) ankle of each patient. The ankles were examined in held-forced positions (anterior drawer test) under local anesthesia. Administering local anesthesia is important to reduce pain and relax the muscles (Figure 1). The athletes had to be relaxed, were lying down with the knee flexed and ankle plantar flexed around 10-20°. A linear probe was used, of 13MHz frequency.

Musculoskeletal ultrasound scans were obtained in dorsal cut for the injured ankle and the uninjured (contralateral) ankle. The distance between the posterior rim of the tibia and talus was measured for each ankle (Figure 2). To diagnose the acute ligament tear as being a complete tear or chronic ligament laxity, the difference between the injured and uninjured ankle had to be greater than 3 mm in the dorsal cut (Ernst approach) (Ernst, Grifka, Gritzan, Kemen & Weber, 1990).

Figure 1. Ultrasound diagnostics of lateral ankle instability (Anterior drawer test)

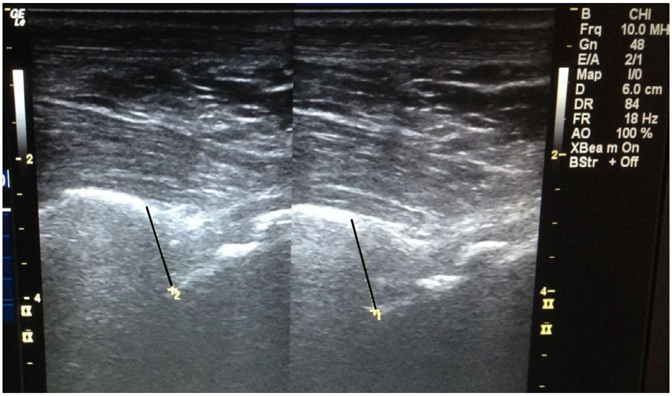

Figure 2. Ultrasound diagnostics of lateral ankle instability: in neutral position (left) and in held-forced position (anterior drawer test) (right). The line depicts the distance between the posterior rim of the tibia and talus (dorsal Ernst approach).

Statistics

Statistica 12.0 (StatSoft, Tulsa, OK) and Excel 2010 (Microsoft, Redmond, WA) were used for the statistical calculations. The t-test (paired and unpaired) was used according to the data distribution. The level of significance was set at $p < 0.05$.

Results

Ultrasound examinations performed under local anesthesia with ankles in held-forced positions (anterior drawer test) demonstrated that the difference between the injured and uninjured ankle was greater than 3 mm in dorsal cuts. We found no significant differences in talocrural joint laxity between acute and chronic ankle instability.

The results are presented in Tables 1 and Figure 3.

Table 1. Ultrasound diagnostics ankle instability results.

	ACUTE (mm)	**CHRONIC** (mm)	**Statistical significance**
Men (n=10)	4.4 ± 1.60	4.55 ± 0.68	NS (0.7999)
Women (n=10)	4.95 ± 1.87	5.75 ± 1.03	NS (0.2264)

$p < 0.05$

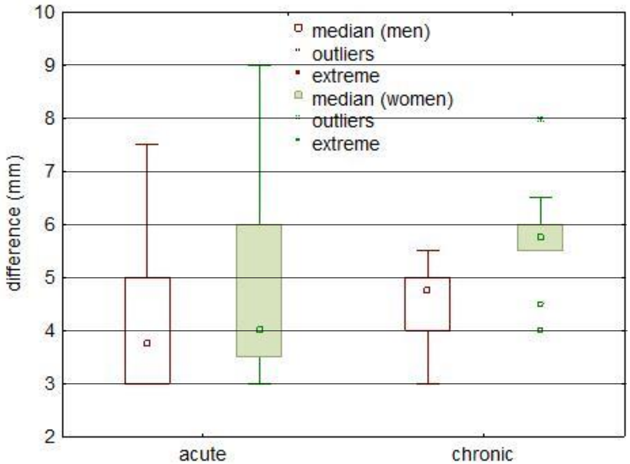

Figure 3. Ultrasound diagnostics ankle instability results.

Discussion

Clinical examination is sometimes insufficient to assess the severity of lateral ankle ligaments. Quantifying talocrural joint laxity after ankle sprain is problematic. The most common tests to assess lateral ankle instability are anterior drawer test and the talar tilt test. The anterior drawer test measures the amount of damage of ATFL, according to the anterior translation of the talus with respect to the tibia (Del Buono, Aweid, Coco & Maffulli, 2013).

Unfortunately, measurement of ankle instability based on manual anterior-drawer tests is problematic and unreliable (Croy, Saliba, Saliba, Anderson & Hertel, 2012).

Stress ultrasonography can image the lateral talocrural joint and allow the measurement of the anterior drawer test (Croy, Koppenhaver, Saliba & Hertel, 2013). Stress views allow objective assessment of displacement under load (Hossain & Thomas, 2014). This US examination technique is reported by authors of some researches.

Karlsson, Bergsten, Lansinger, & Peterson (1989) defined as normal an anterior translation between 2 mm and 9 mm, and as abnormal laxity an absolute anterior displacement of >10 mm, or 3 mm more than the contralateral side.

The 4.8 mm difference between the neutral and anterior-drawer conditions in the involved ankle exceeded the threshold suggested by Gould, Seligson and Gassman

(1980), who indicaded the elongation of the ATFL >4mm would result in "ligament failure". Increases of 2.0 mm to 3,9 mm of anterior laxity have been shown with cadaveric ATFL-sectioning experiments, and the results of the current in vivo study exceeded those findings (Kerkhoffs, Blankevoort & van Dijk, 2005; Croy, Koppenhaver, Saliba & Hertel, 2013).

More than 4 mm anterior displacement is considered positive in the anterior draw test (Hossain, & Thomas, 2014).

Most authors agree, that mechanical instability is present when the side-to-side difference is over 3 mm (Renström & Konradsen, 1997).

Ultrasound evaluation is very dependent upon equipment and operator skill level. The reported diagnostic accuracy for ATFL tears is 95% and 90% for CFL tears (Campbell, Menz, & Isaacs, 1994; Peetrons, Creteur & Bacq, 2004; Maffuli, Longo, Petrillo & Denado, 2012). MRI and CT scans are not usually indicates for acute ankle sprain (Maffuli, Longo, Petrillo & Denado, 2012).

Ultrasound examinations performed under local anesthesia with ankles in held-forced positions (anterior drawer test) demonstrated that all participants in our study had the difference between the injured and uninjured ankle greater than 3 mm in dorsal cuts. Results showed no significant differences in this stress test between acute and chronic mechanic ankle instability. We wanted to compare the ultrasound results of our research with other studies, but we did not find any reports in the literature that could be directly compared.

Conlusion

Acute lateral ankle ligaments injuries can result in acute or chronic mechanic ankle instability that lead to abnormal increase in ultrasonography anterior drawer test in held-forced positions. US imaging in held-forced position provides a safe, reproducible and quantifiable measure of ankle joint stability. It provides useful information when used in side-to-side ankle comparisons.

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EFFECTS OF COMPRESSION CALF SLEEVES ON FORCE PRODUCTION DURING CONCENTRIC AND ECCENTRIC MUSCLE TESTING

Struhár Ivan, Kumstát Michal, Kapounková Kateřina
Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: Muscle strength is one of the key components in almost every sports performance. There are methods which can objectively quantify the actual status of athletes. A considerable amount of research papers has been published. They are focused on torque, position and time parameters with using isokinetic strength testing but often without any practical usage in real conditions. These studies often only describe and compare the sports disciplines or they try to evaluate concentric peak torque changes in time after selected interventions. On the other hand, too little attention is paid to eccentric strength and strength ratio between plantar and dorsiflexion of ankle joint. Strength ratio is well discussed especially for concentric flexion with concentric extension knee muscle strength within the same leg or combination of eccentric flexion and concentric extension. However, questions have been raised about using strength ratio in regards to predicting muscle regeneration or injury´s prevention as well. The objective of presented research is to purpose the effect of different pressure levels of compression calf sleeves used during uphill running on selected isokinetic parameters.

Methods: The study was designed as a double-blind controlled laboratory study because of the elimination of researcher bias. Ten endurance-trained male athletes (age 24.8 ± 3.45 years; body weight 74.11 ± 8.63 kg; body height 1.81 ± 0.08 m; weekly running distance 43.0 ± 5.4 km; 10 km best time 38.0 ± 1.5 min) performed three 8 km treadmill runs at 75% VO_{2max} with 6% incline while wearing compression calf sleeves (two types of graduated compression calf sleeves and one type inversely graduated compression). Maximal voluntary isokinetic concentric contraction and maximal voluntary isokinetic eccentric contraction of plantar flexors and dorsiflexors were recorded at 60°/sec and 120°/sec over 6 contractions with a Humac Norm dynamometer.

Results: No significant differences were found between graduated compression calf sleeves in peak torque of plantar flexors and dorsiflexors during isokinetic concentric and eccentric contraction (60°/s, 120°/s) in pre-test, 24 and 48 hours after the running protocol. Interestingly, analyses showed the significant difference in increasing peak torque of plantar flexors and dorsiflexors (60º/s, 120º/s) for inversely graduated compression calf sleeves during the isokinetic eccentric contraction. A difference between pre-test and 48 hours post run ($p = 0.04123$) was found.

Conclusion: The obtained data indicate that inversely graduated compression calf sleeves (a higher pressure over the calf than over the ankle) may be much more practical during running especially in hilly mountainous terrain not only for running performance but also for reducing delayed onset muscle soreness.

Key words: *dynamometer, exercise, pressure, running, strength ratio*

Introduction

Muscle strength is one the key factors of almost every sports performance. This is often used for assessing the current status of athlete´s in relation to sports training. In the last few years a growing interest in evaluation of athlete´s regeneration has been there (Adamczyk, Krasowska, Boguszewski, & Reaburn, 2016; Mallette, Stewart, & Cheung, 2017; Rahnama, Reilly, Lees, & Graham-Smith, 2003; Struhár, Dovrtělová, & Kapounková, 2014; Vernillo, Temesi, Martin, & Millet, 2017). The key research question is to choose the best method of evaluation (depends on sports performance) which can be used in a real condition. We are strongly confirmed that isokinetic muscle testing can be used for this purpose. However, much uncertainty still exists about the relation between isokinetic dynamometry testing and evaluation of sports recovery. But, according to the study (Greig, 2008) isokinetic dynamometry testing is relevant for assessing muscle force changes, especially after intensive exercise. Furthermore, testing muscle strength may provide the basic insight into the risk of injury. Especially, ipsilateral imbalance (strength between antagonist and agonist) lead to a higher risk of injury which is widely discussed in the literature (Kaminski & Hartsell, 2002; V. H. F. Oliveira, Wiechmann, Narciso, & Deminice, 2017). There is also some evidence to suggest that high intensity running increase impact forces and rear-foot motion (Headlee, Leonard, Hart, Ingersoll, & Hertel, 2008; Niemeyer et al., 2006). Subsequently, we can suppose the higher risk of injuries (for examples ankle sprain).

Nowadays, not only the peak torque, time to peak torque or peak torque/body weight are presented in the literature. According to us, a ratio can be a better predictor for evaluation muscle balance and also predictor of effectiveness the athlete´s recovery process. Several questions remain unanswered at present in a relation which comparison should be referred. Typically, concentric flexion with concentric extension, a combination of dorsiflexion/plantar flexion (concentric or eccentric) or eccentric plantar flexion with concentric dorsiflexion strength ratio are presented. In this investigation, the aim was to assess the influence of compression calf sleeves (CS) associated with isokinetic muscle action.

Methods

Experimental approach to the problem

The main aim of this investigation is to assess the influence of compression calf sleeves associated with isokinetic muscle action. We compared peak torque values and dorsiflexion/plantar flexion strength ratio.

Subjects

Ten trained male runners (age 24.8 ± 3.45 years; body mass index 22.5 ± 1.11 $kg \cdot m^{-2}$; VO_{2max} 62.89 ± 7.68 $mL \cdot kg^{-1} \cdot min^{-1}$, 10 km best time 38.0 ± 1.5 min) volunteered in the study. The study was approved by the university ethics committee (Faculty of Sports Studies, Masaryk University, Czech Republic*)* and all volunteers provided full informed consent. Inclusion criteria included (a) men aged ≥ 18 years (b) any experience with compression calf sleeves before the study protocol (c) free from any active injury (no interruption of training in previous 8 months) (d) training load ≥ 35 $km \cdot week^{-1}$

Measurements

Determination of maximum oxygen uptake

Maximum oxygen uptake (VO_{2max}) was found before the experimental protocol standard treadmill ergometer (Lode Katana). The initial running speed (depends on each participant decision) was between 9-10 $km \cdot h^{-1}$. After this warm up (4 minutes), the test began at 11 $km \cdot h^{-1}$ at a gradient 1 % to correct for the air resistance effect. Then, the speed was increased every 60 seconds until reaching 14 $km \cdot h^{-1}$ (1 $km \cdot h^{-1}$ every 60 seconds). After reaching 14 $km \cdot h^{-1}$, the elevation increased every 30 seconds by 1 % until volitional exhaustion. Each participant was verbally encouraged to exert a maximum effort. The criteria of validity of VO_{2max} was set an identification an identification of a plateau < 150$ml \cdot min^{-1}$ increase in VO_2 despite a further increase in velocity, respiratory exchange ration ≥ 1.1, peak heart rate ≥ 90% of age-predicted maximum heart rate.

Isokinetic measurement

Dorsiflexion and plantarflexion maximal voluntary isokinetic concentric contraction and eccentric contraction strength were evaluated on the dominant leg of the participant. The Measurement was performed on the isokinetic dynamometer (Humac Norm) in a standard position according to the instruction manual (supine position, hip and knee flexed to 60°, the rotation axis of the dynamometer was set up at the level of the ankle´s axis rotation). Rigid straps were attached around participant's ankle, knee and pelvis. The range of motion was set to 20° of plantar flexion and 10° of dorsiflexion during familiarization and testing. Dorsiflexion and plantarflexion strength were recorded at $60^{o} \cdot s^{-1}$, and $120^{o} \cdot s^{-1}$ over 6 contractions with rest intervals of 60 s between each angular velocity. Researcher verbally encouraged participants during testing. Measurement was recorded before, 24 and 48 h after the running testing protocol.

The ratio of plantar flexors and dorsiflexors was calculated. We used the values between eccentric contraction of dorsiflexors and concentric contraction of plantar flexors.

Compression sleeves (CS)

Three different kinds of CS were used in this study. The correct size was of CS was based on the circumference of a calf for each participant (determined by leg circumference at the widest part of the calf) Compression profile are shown in Fig.1. Two types CS was designed as graduated CS (A: 18 mmHg ankle, 15 mmHg calf; B: 25 mmHg ankle, 21 mmHg calf) one of them was inversely graduated CS (C: 18 mmHg ankle, 24 mmHg calf). Pressure values were measured using the Salzmann device (medical stocking tester, MST MK IV. SALZMANN AG ST. GALLEN, Switzerland). Every pair of CS was marked with three randomly chosen letters (the elimination of researcher and participant bias).

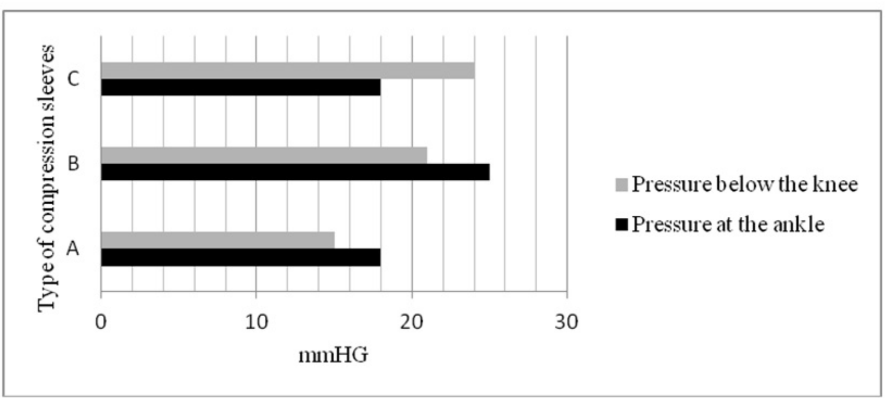

Figure 1 Profile of compression calf sleeves

Experimental design

After arrival at the laboratory, each participant randomly chose one pair of CS without knowing of compression profile. Subsequently, participant undertook 5 min warm up (combination of running and walking) at a self-selected speed. After that, muscle strength evaluation was assessed using an isokinetic dynamometer. Then, the participant had put on CS on both calves and the testing protocol started (8 km running on a treadmill with a 6% elevation rate, the running intensity was set up 75% of personal VO_{2max}). CS were worn during 4 hours post run. Muscle strength measurement was repeated after 24 and 48 h after the exercise protocol for each pair of CS (meaning that each participant visited the laboratory 9 times in 3 blocks of measurements).

Statistical analyses

All statistical analyses were performed using the Statistica 12.0. Data are presented as mean value with standard deviation. Paired t-test for dependent samples was used to data analyses. All p values less than .05 were considered as significant.

Results

The absolute mean peak torque (ankle plantar flexion/dorsiflexion; eccentric isokinetic contraction; angular velocities of 60°/sec and 120°/sec) collected during test sessions are presented in Table 1.

Table 1. Mean values of the absolute peak torque (Nm) for test sessions

Eccentric Contraction									
	A			**B**			**C**		
	Pre-test	24 h post	48 h post	Pre-test	24 h post	48 h post	Pre-test	24 h post	48 h post
PF 60°/sec	246.5	231.1	225.4	234.7	228.4	229.4	249.7	240	256.5
PF 120°/sec	202.3	197.4	192.6	191.3	192.6	192.4	205.9	194.7	185.9
DF 60°/sec	74.6	75.6	77.4	75.9	76.3	77.1	75.9	75.8	74.2
DF 120°/sec	73.3	73.5	75.2	73.7	74.3	73.2	73.5	74	82.2

DF = Dorsiflexion
PF = Plantar flexion
A: 18 mmHg ankle, 15 mmHg calf; ***B*****:** 25 mmHg ankle, 21 mmHg calf; ***C:*** 18 mmHg ankle, 24 mmHg calf

Analyses showed the significant difference in increasing peak torque of plantar flexors and dorsiflexors (60°/s, 120°/s) for inversely graduated (C) CS during the isokinetic eccentric contraction. A difference between pre-test and 48 h post were found for PF 60°/sec ($p = 0.0412$) and DF 120°/sec ($p = 0.0341$).

The ratios of eccentric contraction of dorsiflexors and concentric contraction of plantar flexors are presented in Fig.2.

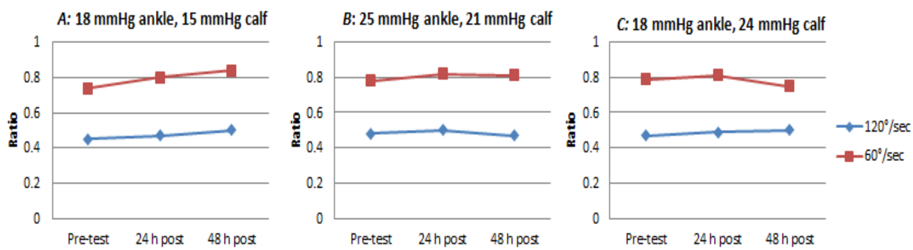

Figure 2. The ratio of eccentric contraction of dorsiflexors and concentric contraction of plantar flexors

Discussion

Isokinetic dynamometry is a relevant method for evaluation of muscle strength. In our study, we wanted to point out to the potential use of dynamometry with regards to the effect of compression calf sleeves. Ankle joint stabilization depends on cocontraction of muscles surrounding a joint. Running and walking are crucial movement in almost every sports discipline. Athletes must rely on cocontraction of ankle muscles (concentric and eccentric actions). Most studies in isokinetic testing have only been carried out for concentric muscle actions (Králová, Novotný, & Řezaninová, 2013; Ustun et al., 2013) which are definitely right for some specific situations. On the other hand, it raises questions about eccentric muscle actions. Running performance depends not only on for concentric muscle actions but also from eccentric contractions. This involves lengthening of the muscles in every step with aim resists the force. Subsequently, eccentric muscle contraction is important for injury prevention. Ankle´s injury may occur during an initial contact of athlete´s leg with the surface. Then, muscles often fail to generate requested an amount of eccentric force to decelerate the movement. There is a large volume of published studies describing this mechanism, but often they describe the hamstring injuries or ankle eversion and inversion torque (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008; Fousekis, Tsepis, Poulmedis, Athanasopoulos, & Vagenas, 2011; S. C. G. Oliveira, Oliveira, Jones, & Natour, 2015). We are strongly convinced that optimal function requires both concentric and eccentric contraction. This is well described in the study (Kaminski & Hartsell, 2002). When the ankle is in a position of plantar flexion and inversion, lateral ankle sprain injury can occur. This can be preventable by the eccentric activity of dorsiflexor and evertor muscles. One possible implication of this is the evaluation of eccentric action of muscles not only for prediction of the ankle injury but also for assessment of the recovery speed with using CS. The major objective of this study was to investigate the effect of different compression calf profile with isokinetic muscle action. We recorded increasing of peak torque (PF 60°/sec DF 120°/sec) for inversely graduated CS (C: 18 mmHg ankle, 24 mmHg calf) during the isokinetic eccentric contraction. A difference between pre-test and 48 h post were found for PF 60°/sec ($p = 0.0412$) and DF 120°/sec ($p = 0.0341$). No significant differences were found between graduated CS (A: 18 mmHg ankle, 15 mmHg calf; B: 25 mmHg ankle, 21 mmHg calf). Equally important to mention is time performance. When we compared the best time during running (41 min 23 s) with the values of maximal peak torque during eccentric actions of test muscle group, we found actually the best values for the same participant. Participant after the conversation with us proved the running downhill (twice a week) and he never had ankle´s sprain injury experience. Using an inversely graduated CS can prevent ankle and muscle injuries and also can be considered a tool for recovery after physical activity especially after intensive interval training.

We also calculated the ratio of plantar flexors and dorsiflexors for each velocity and CS ($\mathbf{A}_{\mathbf{120°/sec}}$**:** $0.45_{\text{Pre-test}}$, $0.47_{\text{24 h post}}$, $0.5_{\text{48 h post}}$; $\mathbf{B}_{\mathbf{120°/sec}}$**:** $0.48_{\text{Pre-test}}$, $0.5_{\text{24 h post}}$, $0.47_{\text{48 h post}}$; $\mathbf{C}_{\mathbf{120°/sec}}$**:** $0.47_{\text{Pre-test}}$, $0.49_{\text{24 h post}}$, $0.5_{\text{48 h post}}$). The progress was recorded for A and C compression profile.

In future investigations, it might be possible to use different velocity spectrum which is more close to real running conditions (180°/sec, 240°/sec). Another important issue for future work is control group and application of a placebo in control group (CS with minimum pressure). Thirdly, it will be interesting compare different length of time wearing CS after running and its effect on strength parameters.

Conclusions

One of the more significant findings to emerge from this study is that using inversely graduated CS lead to better maximum peak torques values of eccentric contractions. The results of this study indicate that using CS has the effect not only during running but also after finishing a physical activity.

Acknowledgements

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THE DIFFERENCE BETWEEN TYPES OF PHYSICAL ACTIVITY ON THE VALUES OF BLOOD PRESSURE IN THE GROUP OF YOUNG WOMEN

Vaculíková Pavlína [1], Struhár Ivan [2], Gimunová Marta [3], Minster David [1], Körnerová Veronika [2], Jeniš Marek [2]

[1]Department of Gymnastics and Combatives, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

[2]Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

[3]Department of Kinesiology, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Purpose: Treatment guidelines for primary and secondary prevention of prehypertension and hypertension confirm the positive effect of no pharmacological lifestyle modifications like weight, sodium, alcohol intake reduction and increasing of regular physical activity. Recently, researchers have shown an increased interest in the relationship between health benefits of regular physical activity (>150 minutes of moderate-intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous-intensity aerobic physical activity) and maintenance of normotension. It is interesting to note, that the type of exercise has a significant effect in case of lower blood pressure (BP). Research has consistently shown that these positive changes are connected with aerobic or endurance exercise training. Besides that, the similar effect of resistance exercise training can be observed. The aim of this study is to investigate the differences between 3 months of regular aerobic and resistance exercise training in the group of prehypertension young women.

Methods: Twelve prehypertension women (age 21.5 ± 1.05 years; body weight 55.21 ± 5.79 kg; body height 1.63 ± 0.12 m; resting systolic blood pressure (SBP) 124.0 ± 6.0 mmHg; resting diastolic blood pressure (DBP) 85 ± 5.0 mmHg) were randomly assigned to two groups (endurance (EG) and resistance group (RG)). Before the study, a ramp test was performed on a standard bicycle ergometer (Ergoline ergoselect 200). Measuring of BP was conducted with digital tonometer (Omron M3) 10 minutes before, 10 and 30 minutes after the each exercise in both groups. The exercise regimen was set up 2 times weekly (exercise programme lasted 50 minutes).

Results: The significant decrease were found between pre-test and post-test in the value of SBP and DBP in RG (SBP_{30min}, p= 0.0332; DBP_{30min}, p= 0.0472). The average decrease between pre-test and post-test was for SBP 6.0 ± 1.0 mmHg and DBP 3.0 ± 1.0 mmHg). The similar results (10 minutes before vs 30 minutes after exercise) have been found in EG (SBP 3.0 ± 1.0 mmHg and DBP 2.0 ± 1.0 mmHg).

*Conclusion***:** From the outcome of our investigation, it is possible to conclude that regular and controlled physical activity is beneficial for improving the values of BP.

Key words: *benefits, diastolic blood pressure, exercise, resistance, systolic blood pressure*

Introduction

Hypertension is currently one of the major risk factors for increasing the prevalence and incidence of cardiovascular disease and consequent cardiovascular morbidity and mortality rates (Lewington et al., 2002). Worldwide, approximately 9.4 million people die from the direct consequences of hypertension every year ('WHO | Causes of death in 2008', 2008). Yet, the treatment guidelines for primary and secondary prevention of prehypertension and hypertension confirm the positive effect of no pharmacological lifestyle modifications like weight, sodium, alcohol intake reduction and increasing of regular physical activity (Korsager Larsen, Matchkov, 2016).

The relationship between health benefits of regular physical activity (>150 minutes of moderate-intensity aerobic physical activity, or at least 75 minutes of vigorous-intensity aerobic physical activity/week) and maintenance of normotension has been analyzed, recently (Pescatello et al., 2004; Asikainen et al., 2003). Even in subjects with a low responsiveness to medical treatment, the physical exercise has been observed to decrease blood pressure (Dimeo et al., 2012). The antihypertensive effect of exercise consists of neurohumoral, vascular and structural adaptations, decreases in catecholamine and total peripheral resistance, improved insulin sensitivity and alterations in vasodilators and vasoconstrictors. Additionally, the post-exercise hypotension, a blood pressure reduction after an exercise, last up to 22 h. (Pescatello et al., 2004). Postexercise hypotensive effect includes vasodilatation of blood vessels in the legs. The blood vessels also may relax after each physical activity because of effects of body warm and production of chemicals (nitric oxide).

It is interesting to note, that a significant effect of the type of exercise on blood pressure decrease was observed. In former studies, the aerobic and endurance exercise training and their positive effects on blood pressure were recommended (Dimeo et al., 2012; Whelton, Chin, Xin, & He, 2002; Pescatello et al., 2004). Nowadays, the similar effect of resistance exercise training has been observed (Veronique A. Cornelissen & Smart, 2013). Moreover, the resistance training positively affects the maintenance of functional capacity and sarcopenia and osteoporosis prevention, especially important in an elderly population (Véronique A. Cornelissen, Fagard, Coeckelberghs, & Vanhees, 2011).

The aim of this study is to investigate the differences between regular aerobic and resistance exercise training performed during 3 months in the group of prehypertension young women.

Methods

Sample

Twelve prehypertension women (age 21.5 ± 1.05 years; body weight 55.21 ± 5.79 kg; body height 1.63 ± 0.12 m; resting systolic blood pressure (SBP) 124.0 ± 6.0 mmHg; resting diastolic blood pressure (DBP) 85 ± 5.0 mmHg; VO_{2max} 38.72 ± 7.49 $ml.kg^{-1}.min^{-1}$, $W_{max/kg}$ 3.85 ± 0.89) volunteered in the study. Participants were randomly divided into two equal groups (endurance (EG) and resistance group (RG)). The study was approved by the University ethics committee (Masaryk University, Czech Republic) and also each participant gave written informed consent form. Inclusion criteria included (a) women aged 20-24 years (b) no history of the cardiovascular disease (c) any experience with similar physical activity programme (d) attendance of participant in EG or RG > 90% on exercise programme.

Measurements

Maximum cardiopulmonary exercise testing

Maximum Oxygen Uptake (VO_{2max}) was found before and after of the experimental protocol on a cycle ergometer (Lode Excalibur). After the warm-up phase (1W/kg body weight, duration 5 minutes), the test started with an increase 0.4 W/kg body weight every 50 seconds until voluntary exhaustion. Examination of a person‘s reactions of its heart, lung, circulatory system to physical stress was performed by breath by breath (METALYZER®3B, CORTEX) system. The pedalling frequency was kept between 60 and 65 rpm. The highest VO_2 value obtained during the test was considered the VO_{2max}.

Blood pressure measurement

Measurements of blood pressure were conducted by digital tonometer (Omron M3) 10 minutes before, 10 and 30 minutes after each exercise in both groups in a quiet environment. Participants had loose-fitting clothes during each measurement and also it was done on the same arm. Blood pressure measurement was recorded at least 1.5 hours after a big meal, coffee or tobacco products. Further, participants had to avoid any strenuous physical activity in a day of the experimental test. The body position was precisely controlled during each measurement (place blood pressure cuff was at mid-arm 2 cm above the elbow, sitting with back support, uncrossed legs, the feet on the floor).

Overview of Study Design

Before the study, participants were randomly assigned to two groups (EG and RG). In the experimental day, the study protocol started with resting in sitting position for 10 minutes. After this, BP was recorded. BP was also measured 10 and 30 minutes after physical activity in both groups in a quiet environment (Researcher and participants were only in the room. It was allowed to speak only before the BP recordings). In order to measure under similar conditions, participants were asked not (a) taking any medications that would affect BP (b) perform any high-intensity exercise at least 24 h before each measurement (c) having a heavy meal (d) drink coffee, alcohol products or other stimulants 3 hours before each test. The exercise regimen was set up 2 times weekly in both groups (exercise programme lasted approximately 50 minutes). Participants were encouraged to keep regularly water consumption intake during exercise programme in both groups.

Resistance exercise programme

The interventions programme was based on a compilation of published physical exercise activities. The exercises were easily understood by participants. The load was set up to 60-65% of one-repetition maximum (1RM). At the beginning, participants in RG started with a pre-workout warm-up (10 min cycling at a self-selected pace, 6 minutes stretching exercises). After the programme, each participant was encouraged to stretch muscle after working out.

The exercise regimen in resistance group was divided (Table 1-2) into two parts (one day- lower body split routine, the second day- upper body split routine).

Table 1. Lower body split routine

Exercise	**Sets**	**Reps**	**Rest**
Leg extension	3	10-12	60 seconds
Squat	2	10-12	60 seconds
Leg press	2	10	90 seconds
4 min rest			
Lying leg curls	3	10-12	60 seconds
Sidestep (with a theraband around knees)	2	14 for each side	30 seconds
Quadruped hip extension (without external load)	2	12	30 seconds
Split squat (without external load)	3	10	60 seconds

Table 2. Upper body split routine

Exercise	Sets	Reps	Rest
Seated bench press	3	10-12	60 seconds
Pec deck flye	2	10-12	60 seconds
Wide-grip lat pulldown	3	12	90 seconds
Incline dumbbell press	3	12	90 seconds
4 min rest			
Overhead dumbbell press	3	10-12	60 seconds
Rope pressdown	3	12	60 seconds
Biceps curl	3	12	60 seconds
Standing cable fly	3	10	60 seconds
Dumbbell hammer curl	3	10	60 seconds
Sit-ups	3	12	90 seconds

Running exercise programme

Running exercise programme (Table 3) was designed as combination between walking and running because of level of our participants.

Table 3. Summary of running exercise programme

Week	Type	Distance (running + walking)
1	1 min run-2 min walk (10x)	4.5 km
2	2 min run-1 min walk (10x)	5.0 km
3	2 min run-2 min walk (10x)	5.5 km
4	2 min run-2 min walk (10x)	6.0 km
5	3 min run-1 min walk (10x)	6.5 km
6	4 min run-2 min walk (8x)	7.0 km
7	6 min run-2 min walk (6x)	7.0 km
8	9 min run-1 min walk (5x)	8.0 km
9	9 min run-1 min walk (5x)	8.0 km
10	12 min run-1 min walk (2x)	8.5 km
11	15 min run-1 min walk (2x)	9.0 km
12	18 min run-2 min walk (2x)	9.0 km

Statistics

All statistical analyses were performed using the Statistica 12.0. Data are presented as means with standard deviation. Paired t-test for dependent samples was used to data analyses.

Results

The data are presented in graphical form (Figure 1-4). The values of post-test$_{30min}$ are from the last two weeks (the average value) of the intervention programme in both groups.

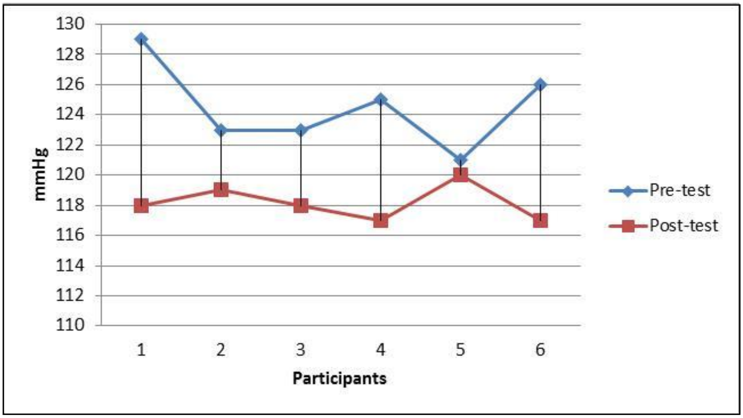

Figure 1. Systolic blood pressure changes in RG (pre-test$_{10min}$ vs.post-test$_{30min}$)

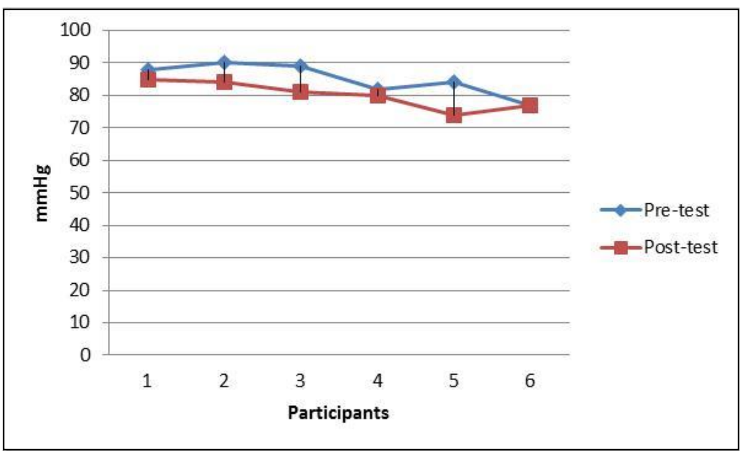

Figure 2. Diastolic blood pressure changes in RG (pre-test$_{10min}$ vs.post-test$_{30min}$)

The significant decrease was found between pre-test and post-test in the value of SBP and DBP in RG (SBP_{30min}, p= 0.0332; DBP_{30min}, p= 0.0472). The average decrease between pre-test and post-test was for SBP -6.0 mmHg and DBP -3.0 mmHg).

The similar results (10 minutes before vs 30 minutes after exercise) have been found in EG (SBP -3.0 mmHg and DBP -2.0 mmHg). On the other hand, the statistical significance was not proved.

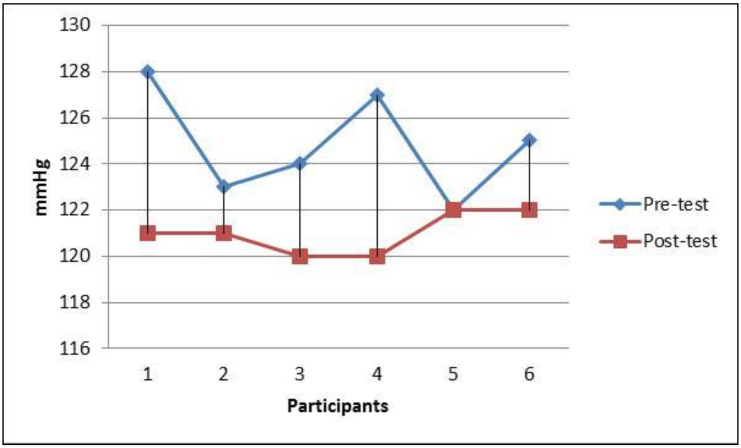

Figure 3. Systolic blood pressure changes in EG (pre-test$_{10min}$ vs.post-test$_{30min}$)

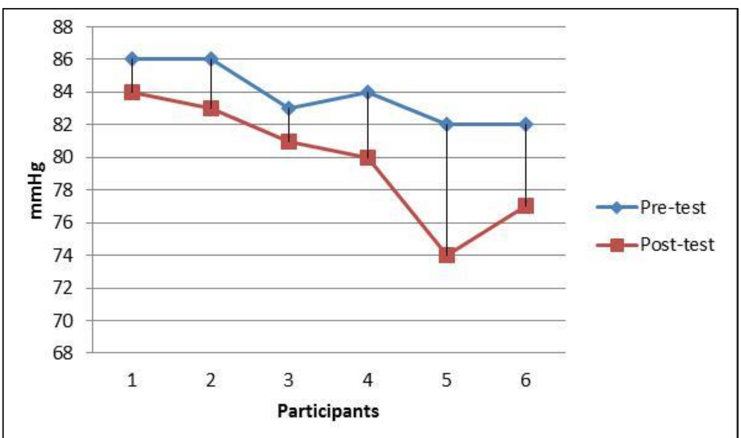

Figure 4. Diastolic blood pressure changes in EG (pre-test$_{10min}$ vs.post-test$_{30min}$)

Discussion

According to World Health Organization and hundreds of scientists, the estimated worldwide number of people (≥25) with hypertension is 1.13 billion (NCD Risk Factor Collaboration (NCD-RisC), 2017). Over the last decade, the influence of physical activity in relation to hypertension prevention has been widely discussed in the literature (Véronique A. Cornelissen, Buys, & Smart, 2013; Veronique A. Cornelissen & Smart, 2013; Inder et al., 2016). Physical activity, in general, is recommended as one of the keys to success in relation to reducing the risk of hypertension. On the other hand, blood pressure is affected also by nutrition, environment, psychosocial stress, behavioural factors such as tobacco use, alcohol intake or sodium and potassium intakes and many of other factors. Subsequently, the risk of hypertension increases with age as a result of stiffening of blood vessels.

The major objective of this study was to investigate the effect of 3 months of regular aerobic and resistance exercise training in the group of prehypertension young women. Our study also provides an important opportunity to understand the role of physical activity in the management of hypertension. It was found that compared types of physical activity had a favorable effect values of SBP and DBP (RG: pre-test$_{10min}$ vs.post-test$_{30min}$, SBP, -6.0 mmHg and DBP, -3.0 mmHg; EG: pre-test$_{10min}$ vs.post-test$_{30min}$, SBP -3.0 mmHg and DBP -2.0 mmHg). There was a significant difference between pre-test$_{10min}$ vs.post-test$_{30min}$ in RG (SBP$_{30min}$, p= 0.0332; DBP$_{30min}$, p= 0.0472). The findings of our study are consistent with those of Cornelissen and Fagard (Véronique A. Cornelissen & Fagard, 2005) who proved the effect of endurance training on blood pressure values (SBP: -2.4mmHg, DBP: -1.6mmHg). Further, the evidence from this study suggests that effect is more pronounced in hypertensive (SBP: -6.9 mmHg, DBP: -4.9 mmHg). Furthermore, besides that, we recorded the increase in values of VO_{2max} in EG (+4.12 ml. kg^{-1}.min^{-1}).

The similar even more positive findings are presented for resistance exercises (Inder et al., 2016) which was similar to our findings. Interestingly, there were also differences in the values of maximum power at the end of VO_{2max} test (+0.32 W/kg) in RG. Contrary to this finding, the Wmax/kg was almost the same (+0.05 W/kg) in EG. The concept of the programme in both groups can explain these findings. The one day of resistance exercise training was focused on lower body split routine, which provides the better maximum power at the end of the test. A possible explanation for higher VO_{2max} might be also the concept of the programme in EG.

A number of potential limitations of this study have to be considered. Firstly, we were working with small group of participants. Secondly, participants were aware of their allocation to groups (the study was conducted without a control group). Thirdly, psychosocial stress and behavioural factors (such as tobacco use, alcohol intake, sodium and potassium intakes) were not recorded during the study. These factors also play a key role in a management of hypertension. Further research needs to examine more closely the links between physical activity and behavioural factors.

Conclusions

Our analysis has shown that regular physical activity is beneficial for the group of prehypertension young women. The study findings add to a growing body of literature on the impact of physical activity on the cardiovascular system.

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RESPIRATORY TRAINING COMBINED WITH AEROBIC TRAINING IN PATIENT WITH DILATED CARDIOMYOPATHY – A CASE STUDY

Vysoký Robert[1,2,4], Kuchrýková Jana[1], Baťalík Ladislav[2,3], Krobot Martin[4], Dosbaba Filip[2,3]
[1]Department of Health Support, Faculty of Sports Studies Masaryk University Brno
[2]Department of Rehabilitation, Faculty Hospital Brno
[3]Department of Internal Cardiology Medicine, Faculty Hospital Brno and Faculty of Medicine Masaryk University Brno
[4]Department of Public Health, Faculty of Medicine Masaryk University Brno

Abstract

Purpose: This case study demonstrates the benefit of expiratory muscle training with the Threshold PEP® combined with aerobic training in a patient suffering from chronic systolic heart failure (CSHF) based on the diagnosis of dilated cardiomyopathy.

CSHF is a serious disease with very bad prognosis. Cardiovascular rehabilitation (CR) reduces the symptoms of CSHF and thus improves the quality of life. The main symptoms presented by the patients with CSHF are exercise-induced dyspnea and fatigue, which limits their ability to perform activities of daily living. Respiratory muscles function can be affected by heart diseases when the patients display weakness and respiratory muscle deterioration. A specific respiratory muscles training programme improves muscle strength, functional capacity and quality of life for CSHF patients with weakened inspiratory and expiratory muscles. Improvement in cardiorespiratory indicators and indicators of exercise tolerance after completing CR reinforces the crucial role of physical activity too.

Methods: 44-year-old patient with dilated cardiomyopathy was assessed: resting echocardiography with left ventricular ejection fraction (LVEF) of 16%, cardiopulmonary exercise testing (CPX), mouth inspiratory (MIP) and expiratory pressures (MEP) measurement, elasticity measurement of the chest and also completed a modified Medical Research Council Dyspnea Questionnaire (mMRC) and Minnesota Living with Heart Failure Questionnaire (MLHFQ). The respiratory training with Threshold PEP® methodology: in accordance with the discovered occlusion expiratory pressure, an expiratory resistance in centimetres of water column was precisely set to meet the patient's needs. Aerobic training complied with the criteria recommended for rehabilitation of patients with cardiovascular diseases issued by the Czech Society of Cardiology. The duration of the programme was set to 10 weeks in total with a frequency of 2 training units per week.

Results: After ten-week-long training with Threshold PEP® combined with aerobic training, a significant change in cardiorespiratory parameters, questionnaires and elasticity of the chest has occurred.

Conclusion: On the basis of positive results, we can indicate that applied respiratory and aerobic training is suitable and practicable for the patient. It positively influences the quality of life of patients with dilated cardiomyopathy, improves cardiorespiratory indicators, reduces effortless breathlessness, and returns to the patient's self-confidence in activities of daily living. However, it is necessary to focus on these problems in more detail in the future.

Key Words*: aerobic training, respiratory training, cardiac rehabilitation, dilated cardiomyopathy, chronic heart failure*

Introduction

Cardiovascular diseases rank among the leading causes of death in the world. In Europe, more than 18 million people suffer from these diseases and 3,9 million of them (i.e. 21.6 %) die each year (EHN, 2017). In 2015, 111 173 people died in total in Czech Republic, where the cardiovascular diseases accounted for 50 969 deaths (45.8 %) of which 438 as a result of cardiomyopathy (i.e. 0.4 % of overall deaths and 0.9 % of deaths due to cardiovascular diseases) (ČSÚ, 2016).

Cardiomyopathy is a heart disease impairing its functionality with incidence of 5–8 cases in 100 000 inhabitants. The prevalence of cardiomyopathy is said to be around 2 % with dilated cardiomyopathy being the most frequent type (90 %). The course of the disease may vary and the prognosis is often bad – 4–10 % of patients with dilated cardiomyopathy die each year, usually due to heart failure, thromboembolic complications or arrhythmia. Unfavourable prognosis results from the ejection fraction < 25 %, expansion of the left ventricle, present arrhythmia or conduction block, low aerobic capacity, age > 55 years and pulmonary pressure of the left ventricle > 20 mmHg (Kim, Choi, & Lee, 2014).

It is known that cardiovascular rehabilitation improves aerobic capacity, heart functionality and patients' quality of life. Together with a respiratory training it can influence positively the strength of respiratory muscles and thus also dyspnea and the performance of the patient. Cardiovascular rehabilitation carried out as a training programme is comprised of a planned, structured and repeated physical activity, whose aim is to improve aerobic capacity. Aerobic capacity consists of several conditions which are essential for performing physical activity. Those are cardiorespiratory endurance (the effectivity of transport and utilization of oxygen), body composition, flexibility and coordination and muscle strength.

The rehabilitation is a training conducted by a specialist, which is prescribed after the evaluation of stress test results individually based upon the stratification of risks. On the grounds of the stress test results, the symptom-limited stress threshold and suitable training intensity of usually 60–80 % of pulse reserve are determined. Concerning effectivity, it is important to define also the type of training (endurance, resistance etc.), the type of physical activity (stationary bicycle, treadmill, walking etc.), the length of the activity and its frequency. Furthermore, it is also suitable to set the goals the patient wants to reach, e.g. improvement of the aerobic capacity or increase in strength. A well-prescribed training programme results in an improvement of cardiopulmonary ability, decrease in overall and cardiovascular mortality and improvement of the patient's physical and psychological state of health (Niebauer, 2011; Thow, 2006; Vysoký et al., 2015).

Respiratory training has its substantial role in cardiovascular rehabilitation. People with chronic heart failure suffer from stress intolerance. The blood perfusion of skeletal muscles is lower due to the decreased function of left ventricle, which can make them easily tired and can result into pain. Lactate, created during muscle activity, is metabolized creating carbon dioxide, which is eliminated by increased ventilation. Thus, a need for intensive ventilation with high level of respiratory work. However, in patients with chronic heart failure we can often find impaired ratio of ventilation to perfusion. This situation is caused by raised pressure in pulmonary arteries, decreased pulmonary elasticity, asynchrony of ventricles, arrhythmia or loss of pulmonary tissue of various etiology. Decreased ventilation, a raise in dead space and inevitable increase in respiratory work together lead to overload and dysfunction of respiratory muscles, which mean that the strength of respiratory muscles is involved in the symptomatology of the patient suffering from heart failure. Weakness of these muscles can lead to aggravation of stress dyspnea and early fatigue, which can be noticed as reduced aerobic capacity. However, this weakening is reversible. Respiratory training is an expiratory tool used for better mucus clearing, expectorating facilitation, raise in muscle strength and endurance of expiratory and inspiratory muscles, for decreasing dyspnea and chest expansion the rise of muscle strength and endurance. Subsequently aerobic capacity and quality of life can be achieved (Dosbaba et al., 2015; Smart, Giallauria, & Dieberg, 2013; Žurková et al., 2015).

The aim of this study is to apply rehabilitation by outpatient respiratory training combined with aerobic training in a patient with dilated cardiomyopathy and to evaluate its results. Considering the given outputs of this article, we have chosen the form of a case study.

Materials and Methods

Patient Z.R. (aged 44, sex: male, height: 190 cm, weight: 82 kg, dominant upper extremity: right) diagnosed with dilated cardiomyopathy, clinically stable with pharmacotherapy prescribed by attending cardiologist. The study was being carried out from June to August 2016 in outpatient CR at the Department of Internal Cardiology Medicine, Faculty Hospital Brno (DICM FH Brno). The methodology of initial and final examination was as follows.

Concerning stress examinations we carried out MIP, MEP and CPX. The measurement of chest expansion was performed before the start of respiratory training. The measurement of chest circumference was performed using a device with a tape-measure. Four measurement points for chest circumference were selected: axillary (the axil area, highest possible point), mesosternal (in the level of stern centre and below the lower angles of shoulder-blades), xiphosternal (at the level of *processus xiphoideus* top) and in the middle between *processus xiphoideus* and *umbilicus*. The measurements at the selected points were always performed at maximum inspiration and maximum expiration. Expansion and flexibility of the given part of chest is then assessed using the differences between the two measurements (Neumannová & Kolek, 2012).

To assess the force of breathing muscles MIP and MEP were measured using Micro RPM, company MS Spiro, Lewiston, USA. The test was performed by measuring the maximum inspiration force and expiration force against a closed valve. Each test was repeated three times with a 30 seconds long break between individual inspiration and expiration (Evans & Whitelaw, 2009).

Together with the patient we filled in the questionnaires evaluating dyspnea mMRC and quality of life in patients suffering from heart failure MLFHQ. To be clear, specific outcomes of the initial and final examinations are presented in the results chapter.

During three months the patient underwent controlled cardiovascular training in outpatient CR at DICM FH Brno twice a week, meaning 20 trainings in total. The respiratory training was held in domestic conditions individually, the check-ups and indications of load increase were done at the CR. After the training programme, all the final examinations were carried out.

Methods of the aerobic training

After the initial examinations the importance of regular physical activity and the outpatient training were introduced to the patient. Every training session started with the examination of the current state of the patient by tissue oxygen saturation measurement with pulse oximeter and evaluation of the haemodynamic values (blood pressure and heart rate). During the training, the patient was monitored with a sporttester (consisting of a belt and a watch), stress blood pressure values monitoring and heart rate measurement, which should have ranged between 121 and 138 bpm (on the grounds of CPX). The training was always held under the supervision of a physiotherapist. The patient was informed about right and safe usage of particular appliances. The stress intensity was set according to the initial examination on each post and it was modified in accordance with the circulation reactions and subjectively perceived effort.

Before training session we carried out rehabilitation anamnestic data. Every training session was divided into three parts: warm-up, training and cool-down. Warm-up lasted usually 10–15 minutes and its aim was to prepare the organism for stress. The main part of the training was the endurance part, which lasted for 30–60 minutes. It was realized at the bicycle ergometer, treadmill or rowing machine. The bicycle ergometer and the treadmill are considered to be only endurance activities, while the rowing machine represents a combination of endurance and resistance training. The final cool-down phase was focused on calming the body down. After the main phase, an activity with minimal stress was engaged, particularly walking or cycling without any load. This phase was ended again with ten-minute stretching in order to optimalize the regeneration (Vysoký et al., 2014; Moc Králová, Pučelíková& Řezaninová, 2016).

Methods of respiratory training

The respiratory training is realized with Threshold® PEP. During the training, the resistance level to 30 % of discovered MEP (in a range of 5–20 cmH_2O), but it is better to reduce the resistance according to the patient's ability and tolerance – respiration cannot be exhaustive, unpleasant or done in a wrong posture. In the therapy, inspiration by nose and a longer expiration by mouth against the resistance of the tool is preferred. Training frequency reaches one fifteen-minute training per day, later rising to 30 minutes (Dosbaba et al., 2015; Neumannová & Zatloukal, 2011).

The patient was instructed how to use Threshold® PEP before the initiation of the respiratory training. The patient has to sit upright, then he inserts the mouthpiece of the respiratory tool into his mouth holding the tool perpendicularly to the mouth, unless the inspiration through the nose and expiration only through Threshold® PEP is too strenuous for the patient. The right respiratory pattern consists of six respiratory cycles per minute with 2 seconds of inspiration, 4 seconds of expiration and 4 seconds of pause between the inspiration and expiration. In case of feeling giddy, headache, palpitations, sudden tachycardia or nausea it is necessary to interrupt the training for at least 15 minutes (Dosbaba et al., 2015; Neumannová & Zatloukal, 2011).

Results

Chest expansion measurement

Based on the measured circumferences (Table 2), the springing and expansion in both upper and lower part of the chest can be stated as normal (circumferences: axillar, mesosternal, xiphosternal, half the distance between *processus xiphoideus* and *umbilicus*). However, expansion in the abdominal area is still decreased.

Table 2.Comparison of initial and final chest expansion measurements

measures cm	final values				initial values			
	1. test	2. test	3. test	max	1. test	2. test	3. test	max
axillar	3,5	3,5	3,5	3,5	3,0	2,0	3,0	3,0
mesosternal	3,5	4,0	3,0	4,0	3,0	2,5	3,0	3,0
xiphosternal	5,0	4,0	4,0	5,0	3,0	3,5	2,5	3,5
½ distance betweenprocessusxyphoideus and umbilicus	3,0	3,0	3,5	3,5	1,0	2,0	1,5	2,0
umbilical	1,5	1,5	1,0	1,5	1,0	0,5	1,0	1,0

Mouth pressure measurement

The highest initial and final values reached are presented in Table 3.

Table 3.Comparison of initial and final mouth pressure values

	final values		initial values	
	recorded values	percent of proper value	recorded values	percent of proper value
MIP	11,4 kPa	94 %	9,0 kPa	74 %
MEP	14,6 kPa	64 %	12,8 kPa	56 %

MIP –maximum inspiratory mouth pressure; MEP – maximum expiratory mouth pressure

Evaluation of questionnaires

The patient is limited by dyspnea only in activities with really high load as can be seen in Table 4 (mMRC = 0). In the MLFHQthe patient reached 20 points out of 105 (corresponds with cca19 % of maximum limitation), in terms of physical score he reached 2 points out of 40 (corresponds with cca 5 % of maximum physical limitation) and in terms of emotions he reached 6 points out of 25 (corresponds with 24 % of maximum emotional limitation).

Table 4. Comparison of initial and final evaluation of mMRC and MLHFQ questionnaires

		points reached				possible range
		final		initial		
mMRC		0		1		0-5
MLHFQ	overall score	20	(19 %)	33	(31 %)	0-105
	physical score	2	(5 %)	8	(20 %)	0-40
	emotional score	6	(24 %)	10	(40 %)	0-25

Cardiopulmonary exercise testing

Both the initial and final examination were done without complications and were terminated for exhaustion without any cardiac complications or symptoms. The patient reached the anaerobic threshold. The results of both the examinations are summarized in Table 5 including the ejection fraction value recorded in resting echocardiogram.

Table 5.Comparison of initial and final results of the spiroergometric examination

	load peak		VAT	
quantity	final	initial	Final	initial
HR	171 bpm	148 bpm	146 bpm	143 bpm
VO_2/kg	29 ml/kg/min	26 ml/kg/min	22 ml/min/kg	25 ml/min/kg
METS	8,3	7,4	6,2	7,2
Wmax.	210 W	160 W	148 W	143 W
RER	1,09	1,02	1,03	1,00
time	25 min 42 s	20 min 39 s	15 min	14 min
BP	117/70 mmHg	93/61 mmHg		
VE	79,9 l/min	66,8 l/min		
VO_2	2,38 l/min	2,07 l/min		
VCO_2	2,59 l/min	2,11 l/min		
$VE/VCO_{2\ slope}$	25,9	29,2		
Ejection fraction:	32 %	19 %		

METS – metabolic equivalent; RER – respiratory exchange ratio; HR – heart rate; BP – blood pressure; VE – pulmonary ventilation per minute; VCO_2 – volume of carbon dioxide expired; VO_2 – volume of oxygen inspired; VO_2/kg – oxygen consumption per kilogram of weight; Wmax. – maximum performance reached during stress; VAT – ventilatory anaerobic threshold

Discussion

Discussion of the respiratory training results

The initial measurement of chest expansion confirmed the previous findings of decreased intensity of breathing into the lower part of chest and abdomen. In the final examination, it is obvious that the expansion in all the measured places raised, most significantly in mesosternal and xiphosternal area. Similarly to the authors of the study Dosbaba et al. (2015) we attribute these findings to better engagement of the respiratory muscles in accordance with the raise in their strength.

When comparing initial values of mouth pressures with the normal range set by Black and Hyatt (1969), we can see that both MIP and MEP are lower than the norm – both values are significantly below the lower threshold of normal range. After the training with Threshold® PEP, the mouth pressures have risen – MIP by 20 % and MEP by 8 %. Based on these results we can say that the strength of the patient's respiratory muscles has risen. Although the increase in MEP was mild when compared to MIP, it is obvious that the expiratory muscles training influences positively the strength of inspiratory muscles.

Discussion of the questionnaire results

Comparison of the initial and final results shows an improvement in dyspnea assessment by one point and also an improvement in the quality of life from initial 33 points to 20, which represents a twelve-percent decrease on a scale for overall limitation. In terms of total points we can see a more considerable improvement in the physical area unlike in the emotional, however, it is important to take in consideration also the range of normal values for each part. In this case, the proportional improvement in physical and emotional area, are roughly the same, particularly 15 % and 16 %, respectively. Thus, we can deduce that the symptoms of dyspnea during activities of daily life and the limitations in emotional and social life were reduced subjectively.

Considering the results of mMRC (dyspnea assessment decreased from level 1 to level 0) we deduce that the reduction of dyspnea symptoms results from the improvement in strength of respiratory muscles as a consequence of expiratory training.

The significant changes in MLHFQ results we attribute mainly to the outpatient controlled training. The patient also found new friends in the group, which influenced positively also the emotional area. We don't mention the influence of the respiratory training on the results as the physical area is focused rather on coping with activities of daily living and exhaustion feelings than on breathing complications. This claim can be supported by the study of Vieira et al. (2014), where the authors concluded that MLHFQ isn't related to MIP as the questionnaire evaluates inadequately respiratory complications. Thus, the questionnaire isn't sensitive enough for recording changes in this area.

Discussion of the effect of aerobic training

The main aim of the training in the patient Z. R. was to improve the functional capacity. Comparing the results of the CPX we can say that we achieved this aim. The $VO_{2\ peak}$ value in the initial examination reached 26 ml/kg/min, which rose by 11,5 % (i.e. to 29 ml/kg/min) thanks to ten-week endurance training. However, $VO_{2\ peak}$ is limited by the necessity of reaching maximum load during the stress test (expressed as RER > 1,1), which is influenced by many factors. The most significant are pharmacotherapy, subjective intolerance of the stress and motivation of the patient. Therefore $VE/VCO_{2\ slope}$ seems to be more relevant prognostic marker (Dosbaba et al., 2017). Looking simultaneously at the respiratory exchange ratio, we can find that in none of the stress tests the desired value of 1,1 was reached.

Arena et al. (2007) divided patients into "ventilatory classes" according to the $VE/VCO_{2\ slope}$. Patients in lower ventilatory class have lower mortality in comparison to the higher classes. The initial $VE/VCO_{2\ slope}$ value of the patient Z. R. was 29,2 – this value corresponds to the upper threshold of the 1stventilatory class. The final value of $VE/VCO_{2\ slope}$ was lower than the initial one, particularly by 11 %. Thus, we can deduce that the aerobic training could contribute to improving the patient's prognosis.

The overall merit of this case study

We believe that the main merit of this paper is the clear and comprehensive description of the possibilities of cardiorespiratory training in a patient with dilated cardiomyopathy. As far as we know, there is no study available in recent literature focusing on combination of the respiratory muscles training and outpatient controlled training in the patients with dilated cardiomyopathy. This paper utilizes the outcomes of the studies presented so far for the purpose of application in clinical practice. Although dilated cardiomyopathy isn't a widespread disease throughout the population, the prognosis of this disease is rather bad. In order to improve the prognosis, it is good to engage not only pharmacotherapy, but also the physical activity of the patients. The significance of physical activity in patients with dilated cardiomyopathy lies not only in the decrease in mortality, but also in positive influence on parameters used as the indication criteria for a heart transplant. The training should not omit the respiratory muscles, which can negatively influence the aerobic capacity of the patients with their weakness.

The main aim of this paper was to evaluate selected cardiorespiratory markers in a patient with dilated cardiomyopathy and to create a summarization of medical knowledge and therapeutic and training procedure. The theoretical knowledge gained in this paper should be applied into clinical practice.

In the future it would be possible to apply the knowledge from this study on more patients and obtain statistically significant results, which would be better in supporting the importance of a combination of respiratory and endurance training. Another possibility would be to add a resistance training to this combination and then compare the obtained results.

In a study of Vieira et al. (2014) it was found that the strength of inspiratory muscles is very decreased in patients suffering from Chagas cardiomyopathy, which then influences the quality of life. The authors believe that specific training of respiratory muscles can be significant in improving dyspnea, consequently influencing positively the quality of life of the patients. Meyer et al. (2001) also recommend training of the respiratory muscles in order to improve the prognosis of the patient. The authors also came to an opinion that MIP might be a suitable marker of prognosis in patients with chronic heart failure. It can be used also in combination with $VO_{2\ peak}$ and ejection fraction of the left ventricle for better stratification of risks in candidates for a heart transplant. The importance of respiratory muscles training is obvious based on the outcomes of these studies.

In a case study, Dosbaba et al. (2015) compared the effect of expiratory muscles training in a patient with chronic heart failure (due to dilated cardiomyopathy) to a patient suffering from ischemic heart disease without any training. The authors discovered that it is possible to improve the pulmonary functions, strength of respiratory muscles, respiratory pattern, chest expansion and functional capacity through expiratory muscles training. The results of this study support the effect of respiratory training found in this paper.

Stolen et al. (2003) were testing 20 patients with dilated cardiomyopathy. The training of these patients took place three times a week for five months. After four weeks, the patients started a resistance training two times a week (at home). The initial intensity was set to 50 % of the $VO_{2\ peak}$ they reached. This value was being constantly raised up to 70 % of $VO_{2\ peak}$. Besides other things, the training raised the functional capacity by 27 %. In our opinion, the higher rise in $VO_{2\ peak}$ was achieved in comparison with the results of the patient Z. R. on one hand by a longer programme, on the other by combination of endurance and resistance training.

Conclusion

Although dilated cardiomyopathy isn't a widespread disease throughout the population, the prognosis of this disease is rather bad. In order to improve the prognosis, it is good to engage not only pharmacotherapy, but also the physical activity of the patients. The significance of physical activity in patients with dilated cardiomyopathy lies not only in the decrease in mortality, but also in positive influence on parameters used as the indication criteria for a heart transplant. The training should not omit the respiratory muscles, which can negatively influence the aerobic capacity of the patients with their weakness.

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LATERAL DIFFERENCE IN THE LEVEL OF THE 9-10 YEARS OLD CZECH FEMALE TENNIS PLAYERS‘ HAND STRENGTH IN THE CONTEXT OF INJURY PREVENTION

Zháněl Jiří[1], Kolínský Roman[1], Pačes Jiří[1], Strašilová Kateřina[1]
[1]Faculty of Sport Studies, Masaryk University Brno

Abstract

From the general viewpoint, the notion of laterality relates to the preference or dominance as to the side asymmetry of the human body. Preference means that the surer, more accurate, coordinated, and often also stronger side is chosen from the viewpoint of motor manifestations. The stated percentage of the left-handed preference is 10-13%, in some sports (e.g. boxing, hockey, tennis), the proportion of left-handers is higher and the percentage of left-handers among the top female players is higher (16%). The one-sided load in tennis can result in an overload of certain muscle groups of the playing hand and in development of muscular dysbalances, which can lead to injury. The research objective was to find out the level of somatic and strength characteristics and to assess lateral differences in the maximum hand strength of the top Czech female tennis players. The research population was composed of female tennis players in the age of 9-10.9 years (n=65, body height: H=145.30±7.50 cm, body weight: W=36.76±6.10 kg) who took part in the regular testing of the Czech Tennis Association in 2000-2015. The basic anthropometric characteristics were measured (height and weight) and also the maximum hand strength using the hand dynamometer (Grip D, Takei). The basic statistical characteristics of anthropometric and strength variables were calculated (n=65, strength of right hand: M_{SR}=18.90±4.82, strength of left hand: M_{SL}=16.70±5.03). It was found that 89% of female players (n=58) used their right hand and 11% their left hand (n=7) as their playing hand. Thus, the percentage of right-handed players was substantially higher than that of left-handed players. The assessment of importance of differences in the level of strength between right-handed (RH) and left-handed (LH) players (Cohen‘s d) proved objectively significant differences in favor of LH players (M_{RH}=18.90±4.60 kp, M_{LH}=24.40±8.40 kp; d=1.07, large). In RH players, an objectively significant difference in the level of strength between the dominant (RH/R) and non-dominant (RH/L) hands was found (M_{RHR}=18.90±4.60 kp, M_{RHL}=15.70±3.40 kp, d=0.70, medium). Also in LH players, an objectively significant difference in the level of strength between the RHL and RHR was found (M_{LHL}=24.40±8.40 kp, M_{LHR}=19.10±6.20 kp, d=0.81, large). The difference between the strength of the dominant and non-dominant hands higher than 15% was found in most female players (51.7% in right-handed players and 85.7%

in left-handed players). In conclusion, it may be stated that objectively significant differences between the level of strength of RH and LH players were found in the examined female players aged 9-10.9 years. The significant differences between the level of strength of the DH and NDH in the population of female players may be a potential cause of injury and it is necessary to pay attention to this fact in training.

Key words: *hand dynamometry, laterality, muscular dysbalances, tennis, tennis players (female)*

Introduction

The research of human laterality has a rather long history, the notion of laterality is understood as a preferred use of one part of the body in comparison with the other one (left or right upper and lower extremity, eye, ear, etc.). Sovák (1962) divides laterality into the functional one (preferred use of one of the paired organs) and shape one (asymmetry of paired organs). From the general viewpoint, the notion of laterality relates to the preference or dominance as to the side asymmetry of the human body but also to the primary use of one brain hemisphere (Coren, 1993; Loffing et al., 2014). When preferring a side, the person usually chooses, from the viewpoint of motor manifestations, the surer, more precise, more coordinated, and often also the stronger one. In the submitted paper, we are going to deal with the problems of the preferred use, more precisely preferring the right (dextrality) or left hand (sinistrality; indeterminate handedness is called ambidexterity). The number of left-handers in the population is quoted between 10-13% (Faurie & Raymond, 2004, Raymond et al., 1996; Sovák, 1962), their percentage in some sports (e.g. boxing, hockey, fencing, tennis) is usually higher (Grouios, 2004; Grouios et al., 2000; Hagemann, 2009; Raymond et al., 1996; Wood, & Aggleton, 1989); e.g. ATP's own analysis of the number of left-handers among the Top 100 players of the ATP Rankings in 2017 found 16% of left-handers. Holtzen (2000), while analyzing the best world male and female players from 1968 to 1999, found only 6.98% of left-handed male players (n=1904) and 7.69% left-handed female players (n=533) among all observed subjects, however, this percentage was considerably higher among the elite male and female players: among ten best world players in the tennis rankings (TOP Ten), it was 24.06% of men and 11.80% of women, among the world players in the first place of the rankings (World Number One), the number of left-handers was 34.4% for men and 30.3% for women, and among the Grand Slam finalists, 22.27% for men and 18.75% for women. Breznik (2013) in his comprehensive study from 1968 to 2011 found 7% of left-handers among male players (n=16732) and 5% among female players (n=16432).

Left-handedness is a provable advantage in tennis, especially among male and female players of the world elite. Faurie a Raymond (2004) explain this by right-handers' insufficient experience when playing against left-handers. Right-handers are more used to the playing style and strategy of right-handed opponents and so playing with the opposite hand from the other side of the court can surprise them (Grouios, 2004; Hagemann, 2009; Loffing et al., 2014). Some authors (Breznik, 2013; Barnett et al., 2006) think that left-handers should have an advantage particularly on faster surfaces (grass or hard courts) because rallies are shorter on them and right-handed players have not enough time to adapt to a different playing style of left-handers.

The contemporary competition tennis is characterized by a faster, more vigorous, and more powerful style of playing, which places much higher demands on the fitness training of players. The most important motor prerequisites in tennis include strength, speed, and coordination (Fernandez-Fernandez et al., 2014; Reid, & Schneiker, 2008; Zháněl et al., 2015). The problems of strength in tennis has been examined by a number of researchers (Carrasco et al., 2010; Fernandez-Fernandez et al., 2014; Reid, et al., 2003; Reid, & Schneiker, 2008; Vodicka et al., 2016; Zháněl et al., 2015) and often used research methods are isokinetic and isometric dynamometry. The long-term repetition of playing activities with the speed-strength character in training and in matches causes an increased load, or rather an overload, in the dominant (playing) arm and players usually have stronger musculature of the dominant upper extremity. When the regeneration after the load is not sufficient or there is an influence of insufficient development of strength in the non-dominant arm, there is an increased risk of possible injuries, especially in the area of the wrist, elbow, shoulder, and torso. The development of muscle dysbalances in tennis players appears already in their young age and proceeds through their active career (Ellenbecker et al., 2006). Motoric activities are parts of a kinematic chain and individual motions are generated from legs and they subsequently shift through the torso into arms and the racket stroke itself. The arm muscles work both concentrically and eccentrically; one of the last segments of the kinematic chain of the service or tennis stroke is the elbow extension before the contact with the ball, which is caused by the triceps contraction that transfers the strength from the torso and the upper arm into the racket. If this chain is interrupted or weakened because of an overload, other muscle groups are involved and they are subjected to an abnormal load (Roetert & Kovacs, 2011). It is not only the strength of the hand and the lower arm what is important, but also the muscle endurance (with respect to the length of matches); an optimum level of the strength of both hands and lower arms makes possible the elimination of joint overload (not only of the wrist and elbow but also the shoulder). Symmetrical development of strength in individual muscle groups is important for maintaining optimum flexibility and muscle balance, which is an important element of injury prevention and optimization of sports performance (Ellenbecker et al., 2006; Roetert & Kovacs, 2011). The synthesis of knowledge makes it evident that the problems of strength in tennis are an important research area because the long-term one-sided load in tennis causes overloading of certain muscle groups of the playing arm. This is connected with the development of significant lateral differences and muscle dysbalances that can become a cause of injury.

Methods

In the framework of this research, we measured the level of maximum strength of hands and the magnitude of lateral differences in Czech junior female tennis players in the context of possible injury development. The research sample group was composed of female tennis players in the age of 9-10.9 years (n=65, body height: H=145.30±7.50 cm, body weight: W= 36.76±6.10 kg, number of training years 4-6) who took part in the regular testing of the Czech Tennis Association in 2000-2015 using the test battery TENDIAG1. From nine items of the test battery, three items related to the research objective were analyzed: basic anthropometric characteristics (body height and weight) and the maximum strength of hands (measured with the hand dynamometer Grip D, Takei). The tested female tennis players carried out alternately two attempts with the left and right hands while standing, the arm was stretched along the body without touching it or having support. The better of the two attempts was considered as the test result. The research data were processed with the Microsoft Excel and STATISTICA 12 software. The research objective was to find out: (1) the level of the observed basic anthropometric and strength characteristics of female tennis players in the age of 9-10.9 years, (2) the number of female players playing with the right and left hands, (3) and if there are notable differences between the strength of the right and left, or rather dominant and non-dominant hands.

Results

It has been statistically verified (chi-square test, variations on goodness-of-fit) that the research data originate from the normal distribution of frequencies. It has been found that among the observed female tennis players (n=65), 89% of players are right-handed (n=58) and only 11% of players are left-handed (n=7). The basic statistical characteristics of the observed variables (body height and weight, maximum strength of the right and left hands) are presented in Table 1.

Table 1. Basic statistical characteristics of the observed variables (female, 9–10.9 years)

Sample	Female (n=65)			
Variables	M	SD	min	max
Age	10.20	0.60	9.0	10.9
Weight (kg)	36.76	6.10	25.8	53.0
Height (cm)	145.30	7.50	130.0	165.0
SR (kp)	18.90	4.82	11.0	36.6
SL (kp)	16.70	5.03	9.1	39.2

Legend:
SR…max. strength of the right hand
SL… max. strength of the left hand
M… mean
SD… standard deviation

The average value of the maximum strength of all female players‘ right hands (SR=18.9±4.82 kp) reaches a higher value than the strength of their left hands (SL=16.7±5.03 kp). With the help of Cohen's d, it has been verified that the difference of the mean values of both hands‘ strength (2.20 kp) is not factually significant (d=0.45, small); thus, the effect of the influence of laterality is small.

Table 2. Strength difference between the right and left hands

Difference	n	%
$D_{(R/L)}$	65	16.7
> 15 %	36	55.4
> 20 %	25	38.5

Legend: $D_{(R/L)}$ *... difference between the right and left hands*

The values presented in Table 2 show that the average difference between the maximum strength of the right and left hands in all observed female players (n=65) is 16.7%; the difference between the right and left hands higher than 15% has been found in 55.4% of players; the difference higher than 20% has been found in 38.5% of players. In the following Table 3, there are presented the results of the analysis of the maximum strength level in right-handed and left-handed players.

Table 3. Maximum strength and difference between the right-handed and left-handed players

Variables	M	SD	Min	Max	$D_{(R/L)}$ >15 %
RHR	18,90	4,60	11,60	36,60	51.7 %
RHL	15,70	3,40	9,10	24,70	
LHR	19,10	6,20	11,00	31,40	85,7 %
LHL	24,40	8,40	14,40	39,20	
DH	19.49	5.45	11.6	39.2	

Legend:
RHR… right-handed/right hand
RHL… right-handed/left hand
LHR… left-handed/right hand
LHL… left-handed/left hand
$D_{(R/L)}$ … difference >15% between the right and left hands
DH…dominant hand (n=65)

The evaluation of the strength level of the dominant (RHR) and non-dominant (RHL) hands in right-handed female players proved factually significant difference in favor of the right hand (M_{RHR}=18.90±4.60 kp, M_{RHL}=15.70±3.40 kp, d=0,79, medium). Factually significant difference between the strength levels of the dominant (LHL) and non-dominant (LHR) hands (M_{LHL}=24.40±8.40 kp, M_{LHR}=19.10±6.20 kp, d=0.72, medium) in favor of the left hand has been found in left-handed female players too. The evaluation of the maximum strength levels of the dominant hands of right-handed and left-handed players (Table 3) proved factually significant differences between the right-handed (RH) and left-handed (LH) players in favor of the left-handed ones (M_{RH}=18.90±4.60 kp, M_{LH}=24.40±8.40 kp; Cohen's d=0.81, large). The established maximum strength level of the dominant (playing) hand of all female players was M=19.5±5.45 kp. The difference (higher than 15%) between the strength of the right and left hands of all players has been found in 62.1% of them; the differences between the maximum strength of the dominant and non-dominant hands (higher than 15%) have been found in 51.7% and 85.7% of the right-handed and left-handed players, respectively.

Discussion

Häger-Ross and Rösblad (2002) give the mean value of the maximum strength of girls aged 9-10 years M=15.3 kp; the sports website Topend Sports (www.topendsports.com/) gives the average value of strength for the girls aged 10-11 years M=16.7 kg; the producer of the dynamometer Grip D (Takei) gives the mean value of strength for the girls aged 10 years M=16.8 kp; Beck and Bös (1995) published the mean value of strength for girls aged 10 years M=16.8 kp; and Gulías-González et al. (2014) found the mean value of strength M=15.1 kp in the sample group of Spanish girls aged 9-10 years. The results of the maximum strength of the dominant (playing) hand in the sample group of the observed female players (M=20.1 kp) are thus in all cases significantly higher than the published values. So, it is evident that thanks to the long-term specific training and match load, young female tennis players achieve significantly above-average values of maximum strength in relatively early youth when compared to the population of girls of the same age. A number of researchers (Nirschl & Sobel, 1981; Ellenbecker, & Davies, 2000; Ellenbecker et al., 2006; Roetert & Kovacs, 2011) agree on the opinion that bilateral differences 10-15% between the extremities can be considered a significant strength imbalance and exceeding the limit of 20% means a significant increase of the risk of injury. The differences exceeding 15% between the strength of the right and left hands in all players (n=65) have been found in 62.1% of them; the differences between the dominant and non-dominant hands have been found in 51.7% and 85.7% of right-handed and left-handed players, respectively. These high differences can be, in accordance with other authors (Ellenbecker et al. 2006; Roetert & Kovacs, 2011; Vodicka et al., 2016), considered a significant risk of injury development.

Conclusion

In the framework of the research, it has been found that among the observed female tennis players aged 9-10.9 years, 89% are right-handed and only 11% left-handed. In the observed players, factually significant differences between the strength level of the dominant (playing) and non-dominant hands have been found, both in the groups of right-handed and left-handed players. Also, factually significant differences have been proved between the strength of the dominant hands of the right-handed players and the dominant hands of the left-handed players in favor of the left-handed ones. The differences higher than 15% between the strength of the right and left hands of all players, or rather between the dominant and non-dominant hands (both of the right-handed and left-handed players), have been found in the overall majority of players. Both coaches and players should pay attention to this fact because it implies possible development of muscle dysbalances and a potential risk of injury. During the training process, the difference between the strength of the dominant and non-dominant hands should be checked on a regular basis. The training should regularly contain exercises strengthening the non-dominant hand and also relaxation and stretching exercises eliminating the development of muscle dysbalances.

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PHYSIOTHERAPY AFTER ANKLE INJURIES IN ORIENTEERING RUNNERS

Smékal David
Palacký University, Faculty of Physical Culture, Olomouc, Czech Republic

Abstract

The most common acute injury in orienteering is a twisted ankle joint. Linde (1986) reports that acute injuries in the area of the ankle joint are present in 36 % of patients with acute locomotor injuries who were injured during orienteering. The reason for these injuries is not only the frequent changes in the character of the terrain that the athlete encounters within the orienteering competition, but also the frequently occurring muscle fatigue and lack of coordination.

The chronic ankle instability is a common complication of these acute injuries in the area of the ankle joint – 10–30 % (Karlsson & Lansinger, 1993). We can divide this chronic instability into three groups and one group is defined as a stable ankle joint – Grade 0 (Leumann et al., 2013). The first group of chronic instability is Grade 1 – moderately instability, which is defined by the anterior drawer test between 10–15 mm and the lateral and medial talar tilt test – angle of 10–15 °. The second group (Grade 2 – substantially unstable) of chronic instability is defined by the anterior drawer test between 15–20 mm and the lateral and medial talar tilt test – angle of 15–20 °. Grade 3 of chronic instability – very unstable – defines an ankle joint that is associated with the medial and lateral tilt of the talus at an angle of more than 20 ° and the anterior drawer test greater than 20 mm.

We focused on improving the functional stability of the ankle joint in physiotherapy. Functional stability is restored especially by sensomotoric and plyometric training. External ankle joint stabilization such as orthosis, taping, kinesiotaping, special running shoes is specific for orienteering. It is essential for the positive effect of physiotherapy to maintain a sufficient period of stabilization of the injured ankle joint in the acute phase of the leg injury.

Key words: *Ankle injuries, orienteering, anterior drawer test, sensomotoric training*

Introduction

The study of Johannson (1986) showed in orienteering a total incidence of three injuries per 1,000 training hours with no gender difference. Most injuries (80.3 %) occurred during training, while the remaining injuries occurred during competition.

The lower extremities were affected in 93.6 % of the male injuries and in 100 % of the female injuries. The majority of injuries (60.6 %) were moderate, while 19.7 % were minor and 19.7 % were major injuries. Of a total number of 28 traumatic injuries, 78.6 % occurred while running on uneven ground, mainly in forests. Among the traumatic injuries, ankle sprains accounted for 57.1 % for both men/women. The majority of these sprains (81.2 %) were moderate (Johannson, 1986). Ekstrand, Roos and Tropp (1988) claims the incidence of ankle sprains was 1.8/1000 hours of competitive time in orienteering event O-ringen.

Ankle sprains can happen through bad luck, but often has to do with tiredness, lack of coordination and loss of concentration. Poor general flexibility plays an important role too (Linde, 1986). Up to 40 % of the patients with acute ankle sprain develop chronic ankle instability either as a mechanical or functional ankle instability. Orienteering is a high-risk sport for chronic ankle instability (Leumann et al., 2013).

The chronic ankle instability is a common complication of the acute ankle injuries – 10-30 % (Karlsson & Lansinger, 1993). We can divide this chronic instability into three groups and one group is defined as a stable ankle joint – Grade 0 (Leumann et al., 2013). The first group of chronic instability is Grade 1 – moderately instability, which is defined by the anterior drawer test between 10-15 mm and the lateral and medial talar tilt test – angle of 10–15 °. The second group (Grade 2 – substantially unstable) of chronic instability is defined by the anterior drawer test between 15–20 mm and the lateral and medial talar tilt test - angle of 15–20 °. Grade 3 of chronic instability - very unstable - defines an ankle joint that is associated with the medial and lateral tilt of the talus at an angle of more than 20 ° and the anterior drawer test greater than 20 mm.

The frequentness of such ankle injuries is quite high. This is the reason for the athletes' trivialization of such injuries and, therefore, the treatment is often insufficient (Hintermann & Hintermann, 1992).

In the pathomechanism of chronic ankle rotational instability, recurrent supination traumata lead to mechanical instability of the lateral ligaments. The anterior talofibular ligament is affected in 80 % of the cases, whereas in 60 % of the cases the calcaneofibular ligament is injured (Hintermann, Boss, & Schäfer, 2002). In about 65 % it is an isolated injury of the anterior talofibulare ligament, in 20 % both anterior talofibular ligament and calcaneofibular ligament are involved (Polzer et al., 2012).

In 25 to 77 % of the cases, tenosynovitis and ruptures of the peroneal tendons are found in association to chronic instability, whereas in 9 % of the cases sinus tarsi syndromes, and syndesmotic insufficiency appear (Leumann, Pagenstert, & Valderrabano, 2010). Long-term cartilage lesions which can be associated with chronic ankle instability probably lead to a high rate of osteoarthritis (Valderrabano, Hintermann, & Fung, 2006).

Conservative treatment should be favored over surgery due to comparable results with fewer complications and significantly lower costs. Surgery should, therefore, be reserved for patients with persistent symptoms, particularly since secondary reconstruction of the ruptured ligaments is possible even years after the injury with results equal to those of primary repair (Polzer et al., 2012).

There are two approaches to conservative treatment: 1) immobilization, usually using a cast, and 2) functional treatment, with a short period of protection using tape, a bandage, or a brace, followed by early weight-bearing, including exercises and neuromuscular training of the ankle. Exercises for range of motion, and neuromuscular training of the ankle, should begin as early as possible. The time to return to sport or work was significantly shorter for functional treatment (Kannus & Renstrom, 1991). Fifteen percent to forty percent of the patient with ankle injuries are reported to have persistent pain, late disability, and instability. In these patients surgery is recommended.

More than 50 different ankle stabilization procedures have been described in the literature. Subsequently, at least another 30 new procedures have been described in the last decade. Many of these studies show unacceptable long-term results involving restrictive motion especially at the subtalar joint, late onset arthritis, residual functional instability, scarring, and other surgical complications (Westlin, Vogler, Albertsson, Arvidsson, & Montgomery, 2003).

The most important point in preventing chronic ankle instability is the correct treatment of the acute ankle sprain. The correct treatment should include adapted immobilization depending on acuteness, external stabilization of the foot and, furthermore, a functional neuromuscular training to slowly establish stability as soon as possible.

We focused on improving the functional stability of the ankle joint in physiotherapy. Functional stability is restored especially by sensomotoric and plyometric training. External ankle joint stabilization (orthosis, taping, kinesiotaping, special running shoes) is specific for orienteering. It is essential for the positive effect of physiotherapy to maintain a sufficient period of stabilization of the injured ankle joint in the acute phase of the leg injury.

Case report

Female patient, 20 years old. Orienteering from 6 years. Patient has had repeated distortion of the right ankle (2–3 times per season). Only two times in a brace. In the last three years with the need for passive stabilization of the right ankle during sport activities. Generalized hypermobility – Beighton score – 9 points.

Examination in February:

Right ankle:

- The medial and lateral tilt of the talus at an angle: 15 °, anterior drawer test: 20 mm.

- ROM: S(a): 20 – 0 – 35; S(p): 20 – 0 – 40, adduction in plantar flexion: + 10° against the other side, pain in the end position, no ligamentous barrier.

- Standing on the limb - significant instability on the right side.

The operation is planned for March. We focused on proprioceptive training – balance pads, posturomed, and gently plyometric training during 4 exercise sessions.

Operation in March:

26.3. – Surgery operation-reconstruction of the lateral ligament – type of operation – WEBER – ILF - tenodesis of peroneus brevis muscle. The proximal part of tendon of peroneus brevis muscle was sutured to the tendon of peroneus longus muscle. The distal part of the tendon is led through the bone channel above the apex of the lateral maleolus and its proximal end is fixed in the area of the origin of fibulotalare anterius ligament to talus (Spiralog anchor).

- Plaster for 4 weeks in dorsal flexion and eversion, then 2 weeks in brace in neutral position.

- Walking on the French crutches.

- Exercise to improve muscle strength and co-contraction in adjacent joints (right knee and hip).

- Imagination exercise in the right ankle.

Examination in May:

Right ankle:

- The medial and lateral tilt of the talus at an angle – not investigated, anterior drawer test – not investigated.

- ROM: S(a): 5 – 0 – 5; S(p): 10 – 0 – 5, adduction in plantar flexion – not investigated, pain in the end position especially in plantar flexion, swelling on the lateral part of ankle, the scar is difficult to move in all directions.

- Walking on the French crutches, gradual load is allowed.

We focused on soft tissue techniques (mobilization of the scar, displacement of individual layers of soft tissues – dermis, epidermis, fascia on the foot, ankle and crural region), softly - active ankle movement, progressive proprioceptive training – in sitting position – “small foot” according Janda, gradual loading of the right limb. Strengthening of the lower limb muscle with using proprioceptive neuromuscular facilitation method – rhythmic stabilization and stabilization reverse.

Full loading of the right limb after two weeks, improvement in soft tissues movement. Proprioceptive training in standing position, lunges, exercise in closed kinetic chains – squats, exercise in Redcord system.

Examination in June:

Right ankle:

- The medial and lateral tilt of the talus at an angle: 5°, anterior drawer test: 5mm.
- ROM: S(a): 15 – 0 – 20; S(p): 20 – 0 – 30, adduction in plantar flexion – same like on the other side, no pain in the end position, no swelling on the lateral part of the ankle, the scar can by freely moved in all directions.
- Walking without restriction (now there is a stable ankle joint).

We focused on progressive proprioceptive training, plyometric training, run on the balance pads, exercise in closed kinetic chains – deep squats, exercise in Redcord system.

We recommended using special footwear or a brace on the ankle during orienteering. It is appropriate to use the tape to improve the stability of the right ankle during sport activities.

Conclusion

The most important point in preventing chronic ankle instability and surgery intervention is the correct treatment of the acute ankle sprain.

To treat an injury of the lateral ligaments of the ankle, functional treatment is currently the treatment of choice. This should consist of PRICE (protection, rest, ice, compression, elevation), NSAID (non-steroidal antiflammatory drugs – diclofenac, ibuprofen, piroxicam), early weight bearing and proprioceptive exercises for improving the coordination of the muscles in the ankle region (coordination of the muscles in lower limb and trunk). For unstable injuries (grades II and III), a semi-rigid ankle brace and supervised rehabilitation should be provided. Operative treatment is recommended in cases of chronic instability only.

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SPORT TRAINING

THE EFFICIENCY OF VARIOUS RECOVERY STRATEGIES AFTER SPECIFIC ENDURANCE PHYSICAL LOAD AMONG SOCCER PLAYERS

Čech Pavol, Vadašová Bibiana, Ružbarský Pavel, Matúš Ivan, Eliaš Tomáš
University of Presov, Faculty of Sports, Presov, the Slovak Republic

Abstract

Purpose. The study deals with evaluation of the lactate response and recovery processes among soccer players after specific endurance physical load using the selected recovery strategies.

Methods. The screened sample consisted of 28 soccer players of U17 and U19 categories, who competed in the top national league (average decimal age 17.0 ± 0.9 years; body height 178.2 ± 4.7 cm; body weight 69.3 ± 6.7 kg; body fat 11.3 ± 4.5 %). The effect of the selected recovery strategies (sport massage, local cryotherapy of lower limbs, whole-body stretching, active movement and passive recovery) on the level of recovery processes was evaluated on the basis of the lactate produced over the 20-minute period after physical load. Participants were subjected to specific endurance physical load using a Yo-Yo intermittent recovery test, level 1. The level of lactate was detected from capillary blood taken from the fingertips and recorded in the intervals of 3, 5, 7, 15 and 20 minutes after physical load. The baseline was the level of lactate recorded before physical load. The study is the part of VEGA 1/0622/15 scientific project titled „The effect of regeneration on recovery of the body after aerobic and anaerobic load in sport".

Results. In terms of lactate metabolism, if compared between the 5^{th} and 15^{th} minute, the greatest decrease of the lactate level was found in participants with active movement recovery (decrease by 50.2 %), followed by massage (49.3 %), local cryotherapy of lower limbs (45.1 %), stretching (43.8 %) and passive recovery (42.4 %). In case of monitoring the entire rest phase, similar results were found, when the greatest lactate clearance was observed in participants with active recovery (decrease by 64.1 %), followed by stretching (55.3 %), massage (54.6 %), local cryotherapy of lower limbs (54.3 %) and, finally, participants with passive recovery (53.1 %). Concerning statistics, Kruskall-Wallis ANOVA was applied; however, no statistical differences were found at the level of $\alpha = 0.05$.

Conclusion. As indicated by the results, the use of active movement recovery strategy appears to be the most efficient after aerobic-anaerobic load.

Key words: *Yo-Yo intermittent recovery test, recovery phase, lactate clearance, massage, stretching, cryotherapy, active movement recovery.*

Introduction

Intermittent nature of physical load in a soccer game puts great demands on players' physical preparedness. Playing performance of a soccer player consists of a wide spectrum of physical activities ranging from walking, running at various paces, jumping, running backwards, etc. Bangsbo (1994) agree in the opinion that the player's actions with a ball only last for 1 to 3 minutes in a soccer game. According to Bloomfield, Polman, & O'Donoghue (2007), the most common physical action is running up to 15 km/h and walking (75-90% from the total covered distance); the remaining 10-25% of actions is performed at speed higher than 15 km/h.

It is the alternation of movement intensity and rapid changes of direction which result in great demands on energy potential and consequently energy expenditure Therefore, the level of recovery processes plays a very important role in sport performance, not only in soccer. According to Bishop, Jones, & Woods (2008) recovery is one of the least understood and most underresearched constituents of the exercise-adaptation cycle. We can define recovery, from a practical perspective, to mean the ability to meet or exceed performance in a particular activity. The recovery process is of particular importance in events where an athlete may have to compete on more than one occasion during a competition in a single day (Monedero & Donne 2000).

In active subjects, the measurement of degree and mechanism of fatigue remains complicated. The most common physiologic indicator is the monitoring of blood lactate concentration. As reported by Gladden (2004), the bulk of the evidence suggests that lactate is an important intermediary in numerous metabolic processes, a particularly mobile fuel for aerobic metabolism, and perhaps a mediator of redox state among various compartments both within and between cells. Previously, it was believed that intense physical activity results in the production of lactate and the accumulation of lactate in exercising muscle is thought to be a major determinant of fatigue (Stamford, Weltman, Moffat, & Sady, 1981). According to Gladden (2004), blood lactate correlated with fatigue, however, it did not cause it. As stated by Martin, Zoeller, Robertson, & Lephart (1998), lactate metabolism and its rate of elimination from blood and muscle are important components of recovery. Due to the strong correlation between concentration of blood lactate and fatigue, the level of lactate is widely used in sports practice to assess the effect of exercise on the body.

Effects of selected recovery strategies, such as massage (Brummit 2008), cryotherapy (Hohenauer, Taeymans, Baeyens, Clarys, & Clijsen, 2015) published in meta-analytical reports are available, as well as meta-analysis of recovery strategies in soccer published by Nédélec et al. (2013). The standard design of studies in this field is a comparison of one or two recovery strategies with passive recovery. Moreover, the authors' findings are often contradictory. This inconsistency is primarily based on various designs used, in terms of various physical load, settings of recovery strategies and time intervals of recording output parameters. The remaining question in soccer and other sport disciplines is which recovery strategy is the most effective in restoring the energy potential and suppressing the negative effects of previous exercises of various intensity, in terms of renewing the ability to repeat a high level of performance.

The goal of study is to evaluate the lactate response and recovery processes among soccer players after specific endurance physical load using the selected recovery strategies.

Methods

A randomized cross-sectional design was used to describe the effect of selected recovery strategies on lactate clearance of soccer players. The screened sample consisted of 28 soccer players of U17 and U19 categories, who competed in the top national league. The participants' average age at the time of measurements was (mean ± standard deviation) 17.0 ± 0.9 years, average body height 178.2 ± 4.7 cm, body weight 69.3 ± 6.7 kg. In terms of body composition, participants had average proportion of fat mass at the level of 11.3 ± 4.5 % and the amount of fat free mass was 61.4 ± 6.2 kg; percentage of muscle mass amounted to 49.6 ± 2.8 %. None of the players had health restrictions at the time of measurement, nor did they use nutritional supplements that could have influenced the results.

The research was conducted at the beginning of the main season, when we assumed the maximum physical preparedness of the players. The coaches of the teams had been instructed so that the players did not perform any strength and endurance training the day before the measurement because it would have reduced muscle glycogen stores and players' energy potential.

The research was carried out in the interior of a sports hall with artificial grass. Before we started to observe the effect of recovery strategies on the players' postexercise recovery processes we performed diagnostics of somatic indicators and body composition as supplementary characteristics of the research group. Body height was measured using a portable stadiometer (SECA 217, Hamburg, Germany) with an accuracy of 0.1 cm. Body weight and indicators of body composition were detected using direct segmental multi-frequency bioelectric impedance analysis (DSM-BIA). Bioimpedance was measured using an In Body 230 device (Biospace Co., Ltd.; Seoul, Korea). Validity and reliability of measurements taken by this device were described in studies by Karelis, Chamberland, Aubertin-Leheudre, & Duval (2013) and Von Hurst et al. (2015). Data were recorded and subsequently processed using Lookin´Body basic software. The measurement took place in a hall, which met standard conditions described in bioimpedance analysis guidelines (Kyle et al., 2004).

The effect of the selected recovery strategies on the level of recovery processes was assessed on the basis of the rate of lactate production and metabolism over a 20-minute postexercise period. As a form of specific endurance physical load, the athletes performed a Yo-Yo intermittent recovery test, level 1, according to guidelines by Krustrup et al. (2003). The authors reported that during the test, the aerobic loading approached maximal values, and the anaerobic energy system was highly taxed.

Lactate production, as a response of a player's body to specific exercise, was assessed on the basis of capillary blood taken from the fingertips. The blood sample was drawn into a 20 µl Na-heparinized capillary tube. For further processing, the blood sample was placed into a cup containing 1 ml of hemolysis solution.

Biochemical analysis of the blood sample was carried out using Biosen C-line Clinic device (EKF-Diagnostic GmbH, Barleben, Germany). Prior to the analysis of blood samples, the device was calibrated with respect to the accuracy of analysis at a low level of lactate (calibration value 3.0 mmol/l, reference value range 2.71 – 3.39 mmol/l) and high level of lactate achieved (calibration value 14.96 mmol/l, reference value range 13.35-16.65 mmol/l).

The level of lactate was recorded in the intervals of 3, 5, 7, 15 and 20 minutes after exercise. The baseline was the level of lactate recorded before exercise. Blood samples collected in the 3^{th}, 5^{th} and 7^{th} minute after exercise were used to capture the culmination of the lactate released into the bloodstream.

After exercise, the participants were subjected to one of the selected recovery processes, namely sport massage, local cryotherapy, whole-body stretching, active movement and passive recovery. Participants were assigned to groups with different recovery strategy randomly, by drawing lots. Participants with passive recovery strategy worked as the control group. Their task was to remain in rest, without any physical activity, during the specified time interval. Sport massage focused on activating muscles of lower limbs for 14 minutes (each leg for 7 minutes) and it was followed by a 4-minute interval of resting in the horizontal position on the massage table. The massage consisted of effleurage and petrissage and was performed by a qualified physiotherapist. Local cryotherapy was targeted at the most loaded muscle groups during the prescribed exercise. The cryotherapy protocol was set for seven minutes with the following focus: in each of the legs, a 3-minute treatment on the anterior compartment of thigh was applied following by a 3-minute treatment on the posterior compartment of thigh and, finally, 1-minute procedure on the calf muscles. Cryotherapy was performed by a certified personnel using Cryo 6 cold air device (Zimmer MedizinSystem GmbH, Neu-Ulm, Germany), which produces cold air up to -30°C. The treatment was completed by a 4-minute rest on the bed. During cryotherapy, the subjective feeling of stabbing pain in the application area was observed and, in such case, the application was moved to another area. The task of participants with active recovery was to perform subjective controlled exercise of low intensity (50-60 % of maximal load) on a cycle ergometer with mechanical setting of work rate. Active movement recovery lasted for 15 minutes. The last recovery procedure was whole-body stretching. Stretching exercises focused on lower limbs accounted for about 70% of exercises. The participants' task was to execute the prescribed stretching exercises according to the task card and controlled by the examiner for 15 minutes. During recovery, participants were not allowed to consume any nutritional supplements that could disrupt or alter the function of metabolism after the exercise.

The level of recovery processes was assessed using the percentage decrease of the blood lactate level between the highest recorded value and the value recorded in the 20th minute after exercise. From the point of lactate metabolism, the percentage decrease of values recorded in the 5th and 15th minute after exercise were evaluated. Statistical significance of differences between characteristics of groups performing various types of recovery, postexercise lactate production and lactate metabolism in the recovery phase was determined using Kruskal-Wallis analysis of variance. The results of the analysis were assessed with a 5 % risk of a false rejection of the null hypothesis ($p< 0.05$). Statistical analysis was carried out using IBM SPSS Statistics, version 20 (IBM SPSS Inc., Chicago, IL).

The study is the part of VEGA 1/0622/15 scientific project titled „The effect of regeneration on recovery of the body after aerobic and anaerobic load in sport".

Results

Table 1. Comparative analysis of basic variables of the observed research groups (Kruskal-Wallis Analysis of Variance)

Variable	MG		SG		CG		AG		PG		K-W Anova		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	χ^2	df	Sig.
BH (cm)	177.8	4.0	178.6	4.8	175.2	6.9	179.0	2.3	178.6	3.9	0.711	4	0.950
BW (kg)	68.0	5.6	67.4	5.7	66.0	10.7	57.7	25.5	67.6	3.6	1.346	4	0.854
Yo-Yo (stages)	61.0	11.7	59.8	10.8	61.8	6.6	66.2	5.0	58.8	6.1	2.076	4	0.722
BV (mmol/l)	1.7	0.2	1.6	0.4	1.6	0.3	1.5	0.5	1.6	0.3	0.557	4	0.968
MV (mmol/l)	10.4	3.4	8.8	2.7	10.4	2.1	12.9	4.5	8.9	1.9	3.224	4	0.521
5´ (mmol/l)	10.1	3.4	8.1	2.9	9.5	3.2	11.4	4.8	8.1	1.9	2.741	4	0.602
15´ (mmol/l)	5.6	3.0	5.1	2.2	5.8	1.9	6.4	2.4	5.1	1.3	1.026	4	0.906
20´ (mmol/l)	5.1	2.8	4.0	1.5	4.7	1.2	4.4	1.3	4.1	1.1	1.142	4	0.888

Legend. MG - group with massage recovery strategy, SG - group with stretching recovery strategy, CG - group with local cryotherapy of lower limbs, AG - group with active physical recovery strategy, PG - control group, group with passive recovery strategy, $\bar{x}\bar{x}$ - mean value, SD - standard deviation, χ^2 - Chi-squared, test criterion of Kruskal-Wallis Anova test, df. - number of degrees of freedom, Sig. - statistical significance, BH - body height, BW - body weight, Yo-Yo - number of stages in Yo-Yo intermittent recovery test, BV - lactate value before physical load (basal value); MV - maximal value of lactate production; 5´- lactate value recorded in the fifth minute after exercise, 15´- lactate value recorded in the fifteenth minute after exercise; 20´- lactate value recorded in the twentieth minute after exercise

Table 1 presents descriptive statistical characteristics and results of comparative analysis of somatic indicators and basic data entering further analysis in terms of assessing the impact of the selected recovery strategies in individual subgroups of research sample. As demonstrated, Kruskal-Wallis Anova did not show any significant differences between the subgroups in any of the above mentioned variables at the chosen level of significance ($p> 0.05$).

When evaluating the lactate metabolism, in terms of the decrease of the blood lactate concentration between the fifth and fifteenth minute of the recovery phase, we recorded changes in absolute values between the tested groups in the range between 3.0 mmol/l in the case of local cryotherapy and 5.0 mmol/l recorded in the control group. However, it is more optimal to evaluate relative changes, graphical comparison of which is depicted in Figure 1. The highest level of lactate clearance was recorded in the group of participants who performed active recovery strategy (50.2 ± 6.7 %). With a small difference, they were followed by the participants with sport massage during the recovery phase, with percentage of lactate clearance during the monitored time interval at the level of 49.3 ± 12.9 %. Participants with local cryotherapy of lower limbs achieved the lactate clearance lower by 5.1 % than participants with active recovery phase (45.1 ± 9.3 %).

The difference of 6.4% was found in participants performing whole-body stretching and the level of lactate metabolism amounted to 43.8 ± 10.5 %. Finally, the lowest level of lactate metabolism was observed in the control group who performed passive recovery (42.4 ± 7.9 %). Kruskal-Wallis Anova showed there were no statistically significant differences between different types of applied recovery strategies, $\chi^2(4) = 2.241$, $p = 0.692$.

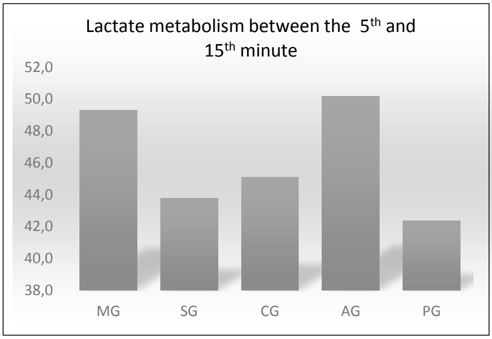

Figure 1. A graphical comparison of lactate metabolism determined as a difference in the level of lactate recorded in the fifth and fifteenth minute of the recovery phase. (MG - group with massage recovery strategy, SG - group with stretching recovery strategy, CG - group with local cryotherapy of lower limbs recovery strategy, AG - group with active physical recovery strategy, PG - control group, group with passive recovery strategy)

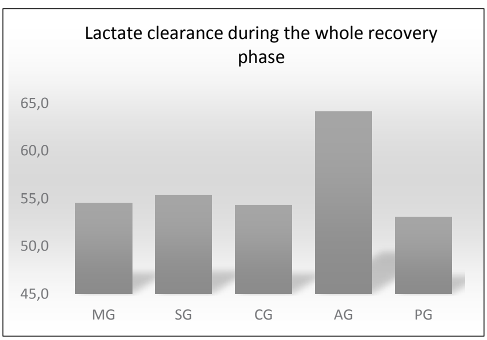

Figure 2. A graphical comparison of changes in the lactate concentration during the recovery phase determined as the difference between the maximum value of lactate level and the value recorded in the twentieth minute of recovery. (MG - group with massage recovery strategy, SG - group with stretching recovery strategy, CG - group with local cryotherapy of lower limbs recovery strategy, AG - group with active physical recovery strategy, PG - control group, research group with passive recovery strategy)

Concerning the total effect of the recovery phase (the decrease of lactate determined as the difference in percentage between the maximum value and the value recorded in the twentieth minute after exercise) we found similar results. The highest level of recovery processes was observed in the group with active physical recovery strategy where the lactate decreased by 64.1 ± 7.3 %. On the contrary, the smallest difference in percentage was found in the control group, namely 11 % and a total decrease of lactate level on average 53.1 ± 8.6 %. As the second most effective recovery strategy we can label whole-body stretching with overall decrease of lactate concentration in the recovery phase by 55.3 ± 4.3 %, following by massage (decrease of lactate level by 54.6 ± 11.9 %) and local cryotherapy of lower limbs which caused decrease of lactate level in the monitored time interval by 54.3 ± 5.8 %. Similarly as in the case of lactate metabolism assessed between the 5th and 15th minute, there were no significant differences in the level of recovery processes in the whole recovery phase ($\chi^2(4) = 5.336$, $p = 0.254$).

Discussion

The effect of massage recovery strategy on lactate concentration

Sport massage is frequently used as a warm-up and recovery technique in sports competitions for athletes (Hongsuwan, Eungpinichpong, Chatchawan, & Yamauchi, 2015) as well as a tool to enhance athletic performance (Holey & Cook, 2003). In our study, the difference in lactate clearance between soccer players with massage and passive recovery during the interval between the 5th and 15th minute of the recovery phase was 6.9 %. The difference in total lactate clearance during the whole recovery interval only made up 1.5%. In neither case were the differences significant.

As our results indicate, we can assume that as long as participants were massaged the lactate cleared better from the blood; as soon as it was finished and participants only rested on the massage tables till the 20th minute, lactate clearance remarkably slowed. On the contrary, these findings are inconsistent with Wiltshire et al. (2010) whose results indicate that sport massage actually impairs removal of lactic acid from exercised muscle and that this is due to a mechanical impairment to postexercise muscle blood flow from rhythmic compression of muscle tissue. On the other hand, similarly to our study, Martin et al. (1998), Hemmings, Smith, Graydon, & Dyson (2000), Robertson, Watt, & Galloway (2004) did not find significant differences in blood lactate concentration following massage or passive rest interventions. In contrast to these findings are the results of the study by Ali, Koushkie, Asadmanesh, & Salesi (2012), who observed the effect of massage and passive recovery on lactate concentration and performance among swimmers. They reported a significant difference in lactate concentration with respect to a different recovery strategy, namely between passive recovery and massage. Moreover, Hilbert, Sforzo, & Swensen (2003) also confirmed that massage can significantly decrease intensity of soreness in subjects receiving a massage treatment, which makes the massage a very important tool in the recovery phase.

The effect of cryotherapy recovery strategy on lactate concentration

The comparison of lactate concentration between participants with local cryotherapy and the control group (passive recovery) showed only minimal insignificant differences in both observed time intervals (2.4 % in lactate metabolism between the 5th and 15th minute of the recovery phase and 1.2 % in lactate clearance during the whole recovery period). The results of our study are only to a limited extent comparable with other authors. In former studies, especially cold water immersion was used with water temperature between 3 and 15 °C or whole body cryotherapy with air temperature between -60 and -110 °C (see meta-analytic review by Hohenauer et al. 2015). Similarly as in our research, no significant differences were observed between application of cryotherapy and passive recovery in the study by Baroni et al. (2010), who tested soccer players after high intensity loading and even recorded better lactate clearance in the group with passive recovery than in the group undergoing immersion cryotherapy. In the complex, however, we can deduct from the results of authors applying cryotherapy a positive effect of this method. Ascensão, Leite, Rebelo, Magalhäes, & Magalhäes (2011) observed the effect of cold and termoneutral water impression in soccer players. The results suggest that cold water immersion immediately after a one-off soccer match reduces muscle damage and discomfort, possibly contributing to a faster recovery of neuromuscular function. Bailey et al. (2007), Ingram, Dawson, Goodman, Wallman, & Beilby (2009), Rowsell, Coutts, Reaburn, & Hill-Haas (2011) state that cold water immersion performed immediately after exercise and repeated throughout the recovery process has proven to be a superior recovery modality when compared with passive recovery.

The effect of stretching recovery strategy on lactate concentration

When we compared the groups with passive stretching recovery and passive recovery we only found small differences in the decrease of blood lactate concentration during the evaluated time periods (1.4 %, 2.2 %, respectively). Based on these results we can assume that a longer interval of executing stretching exercises increased the difference between the effect of passive recovery and stretching. However, these differences were not significant. Otsuki, Fujita, Ikegawa, & Kuno-Mizumura (2011) noted that passive stretching has been reported to reduce blood flow through the stretched muscle because of an elongation of the vessels running parallel to the muscle fibres and an increase in intramuscular pressure. In our results, this assumption was not confirmed, similarly as in the study by Cè et al. (2012), who did not record any difference in lactate concentration due to applied stretching exercises among physically active men. In conclusion, the authors noted that pressure exerted during stretching manoeuvres do not play a significant role on kinetics of blood lactate. On the contrary, Miladi, Temfemo, Mandengue, & Ahmaidi (2011) showed lower lactate values after an exhausting exercise with dynamic stretching compared to passive recovery. The reason can be found in increased cardiac and metabolic response during dynamic stretching.

The effect of active movement recovery strategy on lactate concentration

In studies dealing with recovery after exercises we can very often come across active recovery. Former studies point to the fact that physical activity of low intensity performed during the recovery phase enhances accelerating lactate clearance (see study Martin et al. 1998). In our study, we did not confirm the statistical significance of differences between lactate responses to active movement recovery and passive recovery strategy but the results indicate that active recovery is the most effective strategy in comparison to other recovery methods applied in our study.

Compared to the control group, the group with active recovery achieved by 7.8 % higher lactate clearance in the interval between the 5th and 15th minute of the recovery phase and up to 11 % difference in lactate clearance during the entire recovery phase. These results are consistent with several studies. Results of studies conducted on soccer players (Taoutaou et al., 1996; Koizumi et al., 2011; Yanaoka et al., 2017) have reported that active recovery, performed between 30% and 60% of maximal oxygen consumption and lasting at least 15 min, enhanced blood lactate removal. Martin et al. (1998) tested 10 trained cyclists during 20 minutes of recovery. They observed that active recovery produced significant decreases in both absolute and relative values of blood lactate concentration when compared with sport massage and rest conditions (active recovery lowered lactate concentration by one third more over 20 minutes).

Ali et al. (2012) monitored the effect of active recovery among professional swimmers. A significant difference between passive and active recovery was observed. The reason can be the fact that, according to Martin et al. (1998), active recuperation maintains an elevated metabolic range that does not significantly activate the anaerobic glycolytic pathways. This increase in metabolic range boosts the clearance of lactate through accelerated oxidation.

Conclusion

A physiological profile of a soccer game creates great demands on player's body in terms of the need of repeated high-intensity performance. The comparison of four recovery strategies in soccer players after specific endurance physical load did not reveal any significant differences. As indicated by our results, the use of active movement recovery at moderate intensity appears as the most appropriate alternative. On the other hand, massage and cryotherapy seems to be inappropriate in the context of lactate clearance although studies of other authors suggest that they may also have a positive effect on delayed onset of muscle soreness. In further research, it would be desired to observe not only the effect of recovery protocols on lactate clearance but also to focus on the possibility of repeated performance. Furthermore, since in our study we dealt with intermittent exercise (aerobic-anaerobic load), in further studies it would be desired to assess these recovery strategies after anaerobic physical load.

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THE COMPARISON OF THE INFLUENCE OF THE AGE EFFECT BETWEEN ELITE JUNIOR MALE AND FEMALE TENNIS PLAYERS

Agricola Adrián[1], Zháněl Jiří[2], Bozděch Michal[2]
[1]Faculty of Education, University of Hradec Králové, Czech Republic
[2]Faculty of Sports Studies, Masaryk University Brno, Czech Republic

Abstract

The Age Effect theory is based on the assumption that the athletes born in the beginning of the calendar year are more successful than the athletes born in the end of the year. This “success” comes from the different stage of biological development especially in the junior age. The developmental lead, even just a few months, is often mistaken for a talent.

Several studies show, that the Age Effect is not as strong in girls’ categories. One of the main reasons is that the physical demands doesn´t play such an important role in girls’ case as they play in the case of boys - especially during the time when biological development is not over yet, which makes the differences between individuals even more obvious.

The first aim of this study was to compare the influence of the Age Effect between elite junior male (n = 239) and female (n = 240) tennis players, participant of World Junior Tennis Finals (WJTF) in 2007–2011. The second aim was to compare the influence of the Age Effect between the males (n = 60) and females (n = 60) players in the groups of semifinalists and finalists. The analysis was based on a comparison of the same quarters and same semesters of the year between males and females (Q1 males and Q1 females, Q2 males and Q2 females, etc.). We have used a Shapiro-Wilk test for normality verification and the data was analyzed by the T-Test (modification for percentages) in IBM SPSS software. The results of all players showed, that there were no significant differences between the quarters ($-0{,}37 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$; $0{,}43 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$; $-0{,}83 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$;$0{,}01 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$). The second comparison, based on individual semesters also didn´t confirm any statistically significant differences ($1{,}58 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$; $-1{,}03 < 1{,}96 = t_{Tab\ 0{,}05}$ resp. $2{,}58 = t_{Tab\ 0{,}01}$), neither did the results of semifinalists and finalists ($0{,}2 < 1{,}96 = t_{Tab0{,}05}$ resp. $2{,}58 = t_{Tab0{,}01}$; $-0{,}2 < 1{,}96 = t_{Tab0{,}05}$ resp. $2{,}58 = t_{Tab0{,}01}$) in individual semesters (no analysis between the quarters was made, because of low number of players in these groups).

Although our previous studies confirmed the influence of the Age Effect on the groups of males and females, the comparison of individual quarters and semesters based on genders did not show any significant differences. Because of that, it is

possible to conclude that there is no dominant factor of performance in junior tennis players which would significantly differentiate males and females.

***Key words**: birth date; talent; tennis; sport performance; gender differences*

Introduction

The Age Effect (also known as Relative Age Effect, RAE) has received a lot of attention from sport science researchers during the last few decades. It was first documented in a professional Canadian ice hockey (Barnsley, Thompson & Barnsley, 1985) and its presence has been since proven in other sports too, both team and individual.

The theory of the Age Effect is based on the assumption that children born in the beginning of the calendar year are more successful than the children born in the end of the year. This assumption, however, overlooks the fact that even the children who were born in the same calendar year can still have up to 12 months age difference. If we then realize that 12 months would be 10% of a ten year old child's life, it is a long period of time for a physical and mental development (Agricola, Zháněl & Hubáček, 2013). There is many sport organizations which divide children into categories of two consecutive years of birth, which means, that two young athletes competing in the same age category can be born up to 24 months apart (Delorme, Boiché & Raspaud, 2010). The relative position of a child in the time of selection (selection to a sport club; selection to the national team), whether they are born in the beginning of the year or far from it, may lead to differences in performance (Augste & Lames, 2011; Lames, Augste, Dreckmann, Görsdorf & Schimanski, 2008). Because of that the children who are born earlier in the year and are therefore older, are more easily identified as "talented" or "promising" than their peers born later in the year (Helsen, Van Winckel & Williams, 2005).

Several studies (Aune, Pedersen, Ingvaldsen & Dalen, 2016; Lames et al., 2008; Sedano, Vaeyens & Redondo, 2015; Vincent & Glamser, 2006) also show an impact of the Age Effect based on gender. The effect in girls' categories was not found or it was significantly lower than in the case of boys. It is mostly because the puberty finishes earlier in girls than in boys. The majority of the developmental process is often in the last phase in girls. It means the developmental differences are not as big and the earlier birth date doesn't play such an important role in the performance. However, there are some significant developmental differences between boys during the puberty (Košťálová, 2007; Riegerová, Přidalová & Ulbrichtová, 2006; Segal, Weisfeld & Weisfeld, 1997). Because of that, the developmental lead, connected to the earlier birth date, is a big advantage in the selection process. Different influence of the Age Effect in gender is also connected with another important fact: if the sport is not very physically demanding, there is just a low impact of the Age Effect in girls (Cobley, Baker, Wattie & McKenna, 2009; Lames et al., 2008).

Our previous research has shown an impact of the Age Effect in the male groups (Agricola, 2013; Agricola, Zháněl & Hubáček, 2013) as well as in the female groups (Agricola, 2013; Agricola, Zháněl, Hubáček, Zvonař & Psalman, 2012). Based on this result we can conclude that the physical demanding is what creates the differences in performance and promote the impact of the Age Effect, even in girls ‘group. In our current study we compared the impact of the Age Effect between elite junior male and female tennis players born in different periods of the year to find how strong this effect is.

Methods

The research was made during the World Junior Tennis Finals (2007–2011) in Prostějov, Czech Republic. The tournament is being organized by the International Tennis Federation (ITF) every year and it’s the world championship of the teams of junior male and female tennis players (up to 14 years of age). Every male (n = 16) and female (n = 16) individual team has three players. The birth dates of the individual tennis players were taken from the official materials of the ITF. All the personal data were used with the approval of the players as well as the hosting organization (ITF).

Our goal for this study was to compare the influence of the Age Effect between male and female groups of players. The analysis was based on a comparison of the same quarters (Q) and same semesters (S) of the year between males and females (Q1 males and Q1 females, Q2 males and Q2 females, etc., resp. S1 males and S1 females, S2 males and S2 females). We used a Shapiro-Wilk test for normality verification and the data was then analyzed by the T-Test modification for percentages (Kovář & Blahuš, 1989) in IBM SPSS software. The analysis was made in the group of all players (females: n = 240; males: n = 239) and after that in the group of semifinalists and finalists (females: n = 60; males: n = 60).

Results

The comparison of all players – comparison of quarters

Table 1 and Figure 1 show the frequency distribution of birth of all players in individual months during the years 2007–2011.

Table 1. Frequency distribution of birth of all tennis players (males and females) in 2007–2011

	Male players			**Female players**		
Month	**Frequency distribution**	**Total in quarter**	**%**	**Frequency distribution**	**Total in quarter**	**%**
January	34			32		
February	34	93	38,9	31	98	40,8
March	25			35		
April	36			20		
May	28	82	34,3	27	63	26,3
Jun	18			16		
July	15			21		
August	11	38	15,9	18	53	22,1
September	12			14		
October	13			8		
November	9	26	10,9	9	26	10,8
December	4			9		
Total	**239**	**239**	**100**	**240**	**240**	**100**

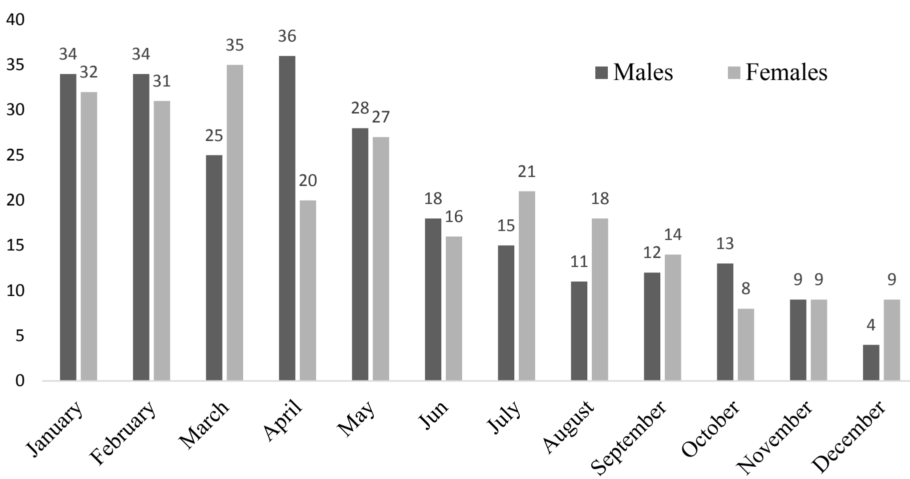

Figure 1. Frequency distribution of birth of all tennis players (males and females) in 2007–2011

Majority of the players who we were testing, both male and female, were born in the beginning of the calendar year (1st quarter). The frequency distribution of the birth in the female group is surprisingly strong in the first three months (1st quarter), where 40,8% of them were born. The data in 2nd and 3rd quarters are relatively balanced, while in male group there is a high frequency distribution of birth in the first half of the year (1st and 2nd quarters).

Table 2. Significance testing between quarters (Q) of all male and female tennis players

Quarter	**Frequency distribution male**	**%**	**Frequency distribution female**	**%**	**t**
Q1	93	38,9	98	40,8	-0,37
Q2	82	34,3	63	26,3	0,43
Q3	38	15,9	53	22,1	-0,83
Q4	26	10,9	26	10,8	0,01
Total	**239**	**100**	**240**	**100**	

The analysis showed no significant difference in any of the cases:
Quarter 1 (January, February, March): $-0,37 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$
Quarter 2 (April, May, June): $0,43 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$
Quarter 3 (July, August, September): $-0,83 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$
Quarter 4 (October, November, December): $0,01 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$

The comparison of all players – comparison of semesters

After the quarters comparison we focused on the comparison of single semesters.

Table 3. Significance testing between semesters for all the male and female tennis players

Semester	**Frequency distribution male**	**%**	**Frequency distribution female**	**%**	**t**
S1	40	66,7	39	65,0	0,2
S2	20	33,3	21	35,0	-0,2
Total	60	100	60	100	

The testing of significance between male and female junior tennis players in individual semesters showed again a negative result:

Semester 1 (Quarter 1 + Quarter 2): $1,58 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$

Semester 2 (Quarter 3 + Quarter 4): $-1,03 < 1,96 = t_{Tab0,05}$ resp. $2,58 = t_{Tab0,01}$

The comparison of semifinalists and finalist – comparison of semesters

There were 60 male and 60 female tennis players in this sample group. Because of such a low number of players, the analysis in quarters was not made. Table 4 shows the significance testing in this sample group.

Table 4. Significance testing between semesters for semifinalists and finalists (male and female tennis players)

Semester	**Frequency distribution male**	**%**	**Frequency distribution female**	**%**	**t**
S1	40	66,7	39	65,0	0,2
S2	20	33,3	21	35,0	-0,2
Total	60	100	60	100	

The analysis showed no significant differences between male and female players in semifinalists and finalist's groups.

Semester 1 (Quarter 1 + Quarter 2): $0{,}2 < 1{,}96 = t_{Tab0,05}$ resp. $2{,}58 = t_{Tab0,01}$
Semester 2 (Quarter 3 + Quarter 4): $-\ 0{,}2 < 1{,}96 = t_{Tab0,05}$ resp. $2{,}58 = t_{Tab0,01}$

Discussion

Most of the authors are dealing with the theory of the Age Effect in team sports, especially in football and ice hockey, but research has also been carried out in many individual sports. It is worth mentioning research made in gymnastics (Hancock, Starkes & Ste-Marie, 2015; Ille & Cadopi, 1999), swimming (Costa, Marques, Louro & Marinho, 2013; Medic, 2009) or skiing and figure skating (Baker, Janning, Wong, Cobley & Schorer, 2014). Unfortunately, there are currently just a very few research papers focusing on the Age Effect's impact on tennis players.

Our research sample group consisted of 239 junior male and 240 junior female tennis players, participants of the World Junior Tennis Finals (WJTF) in 2007–2011. The previous result already shows that there is a strong impact of the Age Effect in males as well as in females. We confirmed this results in the groups of all tennis players (239 males; 240 females) and also in the groups of semifinalists and finalists (60 males; 60 females). An unexpected result was a notably strong impact of the Age Effect in female groups: in the group of all female players and also in the group of semifinalist and finalists. Considering the results of the above studies, we can claim that the strong Age Effect in female groups is coming from the physical demands of tennis.

The next step of our research was to compare the influence of the Age Effect between males and females. We expected finding a lot of differences, coming from an assumption that there is some performance factor(s) typical just for males. However, the results of the analysis did not confirm any of this. There were no significant differences between the quarters (Q1 males - Q1 females; Q2 males - Q2 females, etc.) and the analysis between the semesters (S1 males - S1 females; S2 males - S2 females) did not show any significant differences either. Eventually, an analysis of semifinalists and finalists was made: even in this case the result wasn't significant.

Obtained results show that the performance even in junior level is based on adequate level of all the performance factors, which can limit the performance (reaction time, balance, explosive strength) and also factors which can influence the performance (body height, body weight, endurance, maximum strength) (Zháněl, 2005). The earlier birth date is creating an advantage for players and raising the impact of the Age Effect. It is possible to conclude that there is no dominant factor of performance in junior tennis players which would significantly differentiate males and females based on earlier birth date.

Conclusions

Our final conclusions are similar to the results of the studies made in other sport disciplines and prove that there is a pronounced dominance of players born in the first and second quarters, i.e. in the first semester. There were found no differences in the influence of the Age Effect based on gender, the demands on a high level of all performance factors placed on female players are similar to those places on males. This gives a big advantage to earlier born players. There is unfortunately no key how to successfully supress the influence of the Age Effect yet. The only option is to constantly keep trying to estimate the development, carefully and sensibly predict the future potential of each player. The performance should not be measured solely by sporting performance in junior age; which essentially puts pressure on choosing accelerated players and early specialization in training. More attention should definitely be given to a long-term success and with a consideration of the above mentioned results, it would then become possible to eliminate this effect.

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THE RELATIVE AGE EFFECT IN THE WORLD JUNIOR TENNIS FINALS 2012–2016 (MALE)

Bozděch Michal [1], Nykodým Jiří [1], Agricola Adrián [2], Zháněl Jiří [1]
[1]Faculty of Sports Studies, Masaryk University Brno, Czech Republic
[2]Faculty of Education, University of Hradec Králové, Czech Republic

Abstract

The issue of the Relative Age Effect (RAE) deals with the differences between the chronological age and the degree of the biological development of individuals. Mainly in the period of pubescence, big differences have been noticed in various areas (mental, anthropometric, strength, etc.) between individuals born in the beginning and in the end of the year/season. Biological acceleration resulting from an earlier birth date tends to be confused with sports talent; the influence of RAE shows itself most often in junior categories. This fact has been confirmed by research in a number of collective and individual sports, especially in soccer, ice hockey and tennis. The results of research studies of RAE in tennis have shown that the influence of RAE is more evident in boys than in girls. The aim of the study was to verify the influence of RAE in players of the World Junior Tennis Finals (WJTF) in 2012-2016 (n=240). They were grouped in three-member teams of individual countries, which means 48 players in the age 13-14 years took part each year. The research data (birth dates, results of WJTF matches) has been taken from the official tournament materials of the ITF. The data has been analyzed according to selected criteria (the whole observed period, individual years, semi-final matches, and ranking of players in team nominations). Verification of specific distribution was done by means of the Kolmogorov-Smirnov test (variations on goodness-of-fit) and the chi-squared test (variations on goodness-of-fit). A significant influence of RAE has been statistically proven in the whole sample (n=240) in the observed period 2012-2016 (χ^2=108.6, p=0.00) and in individual years too. A significant influence of RAE has been proven in the players of the semi-final matches (χ^2=42.06, p=0.00) in the whole observed period (2012–2016), however, it was lower than in the players of the whole observed sample. The influence of RAE has been proven in years 2012 (D_{max}=0.51, CV=0.375) and 2016 (D_{max}=0.59, CV=0.375) of semi-final matches in individual years. The influence of RAE has been proven according to the criterion 'ranking of players in team nominations' (1st, 2nd or 3rd player); the higher influence of RAE was observed in the first nominated players χ^2=44.68, p=0.00) than in the second nominated players (χ^2=38.14, p=0.00) or the third ones (χ^2=29.37, p=0.00). It can be stated that in the observed sample of tennis players, the influence of RAE has been confirmed in the whole observed period; a lower influence has been found in

the players of semi-final matches. Further, it has been found that the influence of RAE shows itself also in players' nominations of individual national teams. The mentioned conclusions can be considered important for sports practice, especially for coaches, athletes and also parents.

Key words: *talent, pubescence, sport, biological age, chronological age*

Introduction

The issue of Relative Age Effect (RAE) was first addressed in the education system. Green and Simmons (1962) found that pupils born in the first half of the year had a better learning assessment than the pupils of the same class born in the second half of the year. Similarly, most recent studies have confirmed that pupils born in the first half of the year are more biologically mature in the period of pubescence; this, however, does not mean that after the end of the pubescence period, they will be still marked better than pupils born in the second half of the year (Jeronimus et al., 2015). In the professional publications from the field of sports, the term relative age effect is most frequently used; however, we can also come across the terms birth date effect (Karcher et al., 2014), birth quarter (Larouche et al., 2010), age effect (Agricola et al., 2013). In this study, we will use the most commonly used term relative age effect (RAE).The effect of date of birth in sport was already dealt with by Grondin et al. (1983); the first ones who called this phenomenon 'relative age effect' in the area of sport were Barnsley et al. (1985). The authors found an almost linear relationship in the players of Canadian Junior Hockey League between the date of birth of the players and the number of players in individual quarters of the year and noted that their performance was influenced by the advantage of date of birth rather than by the influence of sports talent. Another study (Barnley & Thompson, 1988) showed a significant influence of the RAE in the NHL players, while the RAE was not significant in the third league. The presented study is based on an extensive literary research of 130 scientific publications aimed at the issue of RAEin sport. It was found that most RAE researches were devoted to soccer (60), ice hockey (20), tennis (12) and handball (9).When comparing men and women, it was determined that the effect of RAE is more evident in males than females. Filipčič (2001) found that the influence of RAE is evident in the U12-U16 categories of male tennis players and in the U12-U14 categories of female tennis players; it has not been proven in the U18 (male) and U16-U18 (female) categories. Interestingly, there are different results in two publications: Pacharoni et al. (2014) found that the tennis players of Brazilian and South American tennis league (U12-U18) had shown the influence of RAE, but the category of professionals (ATP) not any more. On the other hand, Ulbricht et al. (2015) found that the influence of RAE was always stronger at the higher performance level than at the previous level in the German league (DTB) and in the German professional tennis players. Ulbricht et al. (2015) further demonstrated links between the RAE and motor skill level, but found no links between the influence of RAE and fitness abilities, anthropometric and biological characteristics. Loffing et al. (2010) found that the influence of RAE is more prominent in men (aged 16-36) playing on the international level with their right hand than in players who prefer the left hand. As follows from the previous synthesis of findings, the date of birth is an important factor in the selection of sports talent. The long-term examined issue of RAE has been addressed in a number of sports, mainly in soccer, ice hockey and tennis. Our study builds on studies by Agricola et al. (2012, 2013), which confirmed the influence of RAE in male and female players in the tournaments of the World Junior Tennis Finals (WJTF) in 2007-2011.

Methods

The WJTF tournament has been organized by the International Tennis Federation (ITF) annually since 1991, the tournament has been held in Prostějov (CZE) since 1998. The tournament is attended by the winning national teams of boys and girls from regional qualifications and the teams of the organizing country,32national teams (16 males, 16females) participate in the WJTF tournament every year; 3 players are nominated for each team (i.e. 48 male players and48 female players).The presented data are the result of the analysis of 2012-2016 research data on tennis players (males), the participants of the WJTF tournament aged 13-14 (n=240).The research data were obtained from the official ITF materials (date of birth, nationality and ranking in team nomination, semi-finalists and finalists) and were analysed with the use of descriptive method (relative and absolute frequencies, arithmetic mean) and inferential statistics (Chi-Square test (χ^2), Kolmogorov-Smirnov test, both variations on goodness-of-fit). To assess the match of the distribution of expected values with the distribution of empirical (observed) values, we used for calculation the Chi-Squaretest (χ^2) because of the large scale of the file. To determine the distribution of the frequencies of expected data, we obtained from the data.un.org database the data on the number of children born in individual months and years, from which we consequently compiled the expected data for each quarter($Q_{1\text{-}4}$; Q_1=24.12%; Q_2=24.66%; Q_3=26.49%; Q_4=24.73%). For the semi-finalist group, the Kolmogorov-Smirnov test was used to assess the frequency distribution because of the small size of the file.

In light of the above described research problem, we formulated the following research questions:

Is the RAE influence apparent in the WJTF 2012-2016 tennis players:

(1) in individual years?
(2) in the period of 2012-2016?
(3) in semi-final matches in individual years?
(4) in semi-final matches in the period of 2012-2016?
(5) in rankings of nominated players in the period of 2012-2016?

Results

In the result section, we have gradually dealt with the influence of RAE in individual years as well as the whole period of 2012-2016, in semi-final matches, and the influence on the ranking of nominated players.

The RAE in WJTF players in individual years

Table 1 presents the summary of absolute and relative values of the frequencies in the quarters of individual years and the calculated values $\chi^2$for the assessment of the strength of RAE influence. Table 1 shows to us that the year 2014 has the largest difference between Q_1 and Q_4 (25 players, i.e. 52.1%) and the smallest difference was found in 2012 (18 players, i.e. 37.5%).

Table 1. The RAE in individual years

Years (n=48)	Q_1 (%)	Q_2 (%)	Q_3 (%)	Q_4 (%)	χ^2	p
2012	20 (41.67)	17 (35.42)	9 (18.75)	2 (4.17)	16.25	.00
2013	24 (50.00)	12 (25.00)	8 (16.67)	4 (8.33)	18.52	.00
2014	29 (60.42)	8 (16.67)	7 (14.58)	4 (8.33)	32.73	.00
2015	25 (52.08)	16 (33.33)	3 (6.25)	4 (8.33)	27.53	.00
2016	26 (54.17)	11 (22.92)	7 (14.58)	4 (8.33)	23.73	.00

Legend: Q_i...quarter of the year, χ2... chi-square values, p...p-values

The lowest value of $\chi^2$was found in 2012 (χ^2=16.25), this value indicating the smallest difference between the observed and the expected frequencies; the largest difference between the frequencies is in 2014 (χ^2=32.73). We can state that in all the years of the monitored period 2012–2016, an insufficient correspondence between the observed and expected frequency of data was found; therefore the RAE influence can be considered significant.

The RAE in all WJTF players (male) in 2012-2016

Figure 1 describes the distribution of all the participants of the tournament from the period of 2012-2016 by the date of birth in individual quarters, along with the inserted trend line.

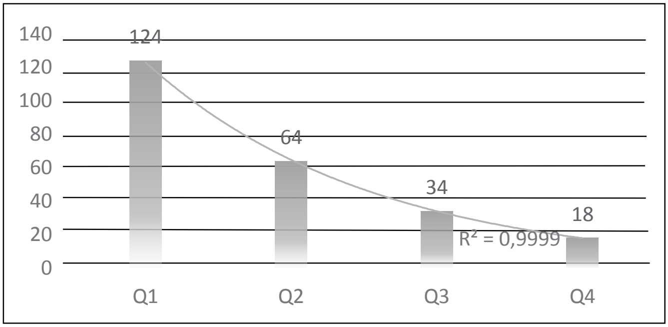

Figure 1 Distribution of date of birth of all the players in the reference period according to the quarters of the year

The progress of the exponential function of the trend (Figure 1, R^2=0.99) shows a decreasing tendency of frequencies in individual quarters $Q_1$to Q_4. The difference between the frequencies in Q_1 and $Q_4$is 106 players (i.e. 44.2%), which means that there are 6.8 times more players in Q_1than players in Q_4. For a greater clarity, we will give the absolute frequencies from Figure 1 in their relative values: Q_1=51.7%, Q_2=26.7%, Q_3=14.4%, Q_4=7.5%. The match of the theoretical distribution of frequencies with the distribution of the empirical data of the research group (i.e. the classification of individual players in 4 quarters by month of birth) was evaluated by calculating the value of Chi-Square test (χ^2=108.7, p=0.00). The larger the deviation between the observed and expected frequencies, the higher is the value of χ^2 and the stronger is the statement about the RAE influence. The calculated value of χ^2 and the level of significance (p=0.00) thus indicate a lack of good correspondence between the theoretical and empirical frequency distributions; the RAE influence can be in this case considered as proven and very strong.

The RAE in semi-final matches in individual years and the whole monitored period

The RAE influence on participants in the semi-final matches of the tournament is presented in the form of absolute and relative values in Table 2. The impact of RAE was assessed for individual years with the use of Kolmogorov-Smirnov test and χ^2test (for 2012-16).

Table 2. The RAE influence on semi-finals

Years	Q_1	Q_2	Q_3	Q_4	D_{max}	CV
2012 (n=12)	7 (58.3%)	5 (41.7%)	0 (0.0%)	0 (0.0%)	.51	.375
2013 (n=12)	7 (58.3%)	2 (16.7%)	2 (16.7%)	1 (8.3%)	.34	.375
2014 (n=12)	6 (50.0%)	2 (16.7%)	2 (16.7%)	2 (16.7%)	.29	.375
2015 (n=12)	4 (33.3%)	6 (50.0%)	1 (8.3%)	1 (8.3%)	.35	.375
2016 (n=12)	10 (83.3%)	2 (16.7%)	0 (0.0%)	0 (0.0%)	.59	.375
2012-16 (n=60)	34 (56.7%)	17 (28.3%)	5 (8.3%)	4 (6.7%)	42.06*	0.00**

*Legend: D_{max}...maximum difference between the cumulative proportions of both samples, CV... Critical Values, *...c^2 test, **...p-value for c^2 test*

The value of D_{max} is greater than the critical value (CV=0.375) in 2012 (D_{max}=0.51) and 2016 (D_{max}=0.59), in these years the distribution of the data of observed frequency does not match the expected frequency; and vice versa, the value of D_{max} is less than the critical value in 2013 (D_{max}=0.34), 2014 (D_{max}=0.29) and 2015 (D_{max}=0.35), and we can conclude that the data distribution of the observed frequency matches the expected data frequency. From the above we can state that the RAE was only demonstrated in participants in semi-finals in 2012, 2016.

The RAE influence on rankings of nominated players in the whole monitored period

Since the players are nominated for the tournament according to the current rankings, we wanted to verify the influence of RAE on the order of the nominated players; the result of this analysis is shown in Table 3.

Table 3. Date of birth impact on nomination ranking in the whole monitored period

Nominated	Q_1 (%)	Q_2 (%)	Q_3 (%)	Q_4 (%)	$\overline{\ }^{2}$	p
1st (n=80)	45 (56.3)	18 (22.5)	9 (11.3)	8 (10.0)	44.68	.00
2nd (n=80)	41 (51.3)	22 (27.5)	14 (17.5)	3 (3.8)	38.14	.00
3rd (n=80)	38 (47.5)	24 (30.0)	11 (13.8)	7 (8.8)	29.37	.00

Similarly to the previous findings, there is a clear predominance of boys born in the first half of the year (resp. Q_1). The biggest difference between Q_1 and $Q_4$is for the 2nd nominated (38, i.e. 47.5%). On the contrary, the smallest difference is for the 3rd nominated (31, i.e. 38.8%). The RAE impact was demonstrated at all nomination levels (1st-3rd nominated), but we can state that the value of χ^2 decreases with the nomination rank, therefore the influence of date of birth has an effect also on the order of nominations.

Discussion

The result of the research indicates that the WJTF players showed an influence of RAE in all cases in individual years. The lowest value of χ^2 was found in 2012, the highest value in 2014; it can be concluded that the strength of RAE influence was fluctuating in 2012-2016. The authors Agricola et al. (2013) found a significant difference between individual quarters in their research of RAE in malesduring 2007-2011 (Q_1 and Q_3; Q_1 and Q_4; Q_2 and Q_3; Q_2 and Q_4). From the data reported by the authors, we calculated the value of chi-square, which is 59.37 (p=0.00); comparing values from 2007-2011 (χ^2=59.37; p=0.00) and 2012-2016 (χ^2 =108.68; p=0.00), it can be stated that the value of χ^2 in the years 2012-2016 is almost double. Zháněl et al. (2011) studied the RAE influence also in females in 2007-2009 and found a significant RAE influence too, although lower (χ^2=30.64, p=0.00) than in the male group. Also other authors have come to the same conclusion that the RAEinfluence is stronger in males than in females, for instance Filipčič (2001) in tennis, Müller et al. (2017) in the Children's Winter Games 2016 (12-15 years) and Rubajczyk et al. (2017) in basketball (male U14-U20; female U14-U22). While our research has shown a significant influence of RAE in junior tennis players (male) in 2012-2016, which has been confirmed in junior tennis also by other authors, this influence is less significant on the professional level (ATP) - Moreira et al. (2017).

Conclusion

The results of the research, focused on the assessment of the influence of RAE in male players of the WJTF in the years 2012-2016 (n=240), showed that the RAE influence had been demonstrated in individual years as well as throughout all the monitored period. In assessing the RAE influence in the players of semi-final matches, once again its statistical significance was demonstrated both in individual years and in the whole observed period. The RAE influence on ranking of nominated players was proven in all positions in teams (1-3); the strongest RAE influence was shown in players nominated in the first position and the weakest in the players nominated in the third position in their team.

The realized results provide significant suggestions for practice; it is clear that the (not only) biological benefits of the players linked with their date of birth are significant in the nomination of players. It is up to the trainers' judgement not to confuse only this advantage with sports talent (in case of players born at the beginning of the year). Therefore the trainers of youth categories, parents and athletes should be familiar with the issue of RAE influence.

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THE PHYSIQUE OF NATIONAL OLYMPIC TEAMS AND IMPLICATIONS FOR TALENT SELECTION

Grasgruber Pavel, Hlavoňová Zuzana, Svobodová Lenka, Cacek Jan
Masaryk University, Faculty of Sports Studies, Brno, Czech Republic

Abstract

In this study, inspired by the classical work of Hirata (1966), we compared body dimensions (height, weight, body mass index/BMI) of national male Olympic teams at the Summer Olympic Games 2000-2016. The results show that the national averages of height and BMI from the same regions are mutually similar. The mean height of Olympic teams is highly correlated with the mean height of young men in their native countries, and mean BMI values from certain regions show consistent tendencies. These data indicate that average physical characteristics of national Olympic teams reflect the body type prevalent in their native populations, which may have very important practical implications for talent selection strategies. A specific case is that of nations of the former Yugoslavia that have the tallest averages of height among all the Olympic teams and whose physical characteristics have been investigated within a separate anthropometric project.

Key words: *Olympic athletes, physique, race, ethnicity, height, BMI*

Introduction

The topic of racial or ethnic differences in sports performance is often hotly debated by the general public, but its detailed scientific investigation is still hampered by social taboo. Certain advancement has been achieved in the study of specific anthropometric and physiological characteristics in athletes of Sub-Saharan African ancestry [1-8] but our ideas about the sports potential of other world regions remain foggy and limited, and this subject thus notoriously gets into hands of sensational journalism [9].

Although physiological factors such as running economy, VO_2 max. and muscle fiber composition are fundamental in many sports and can be measured quite easily, general sports predispositions are more strongly determined by basic physical characteristics (height, body proportions, somatotype). Ethnic differences in height and body proportions can be easily compared as well, but a much more difficult issue is the genetic potential for somatotype (muscle development) because it is inevitably influenced by enviromental factors (the level of nutrition and physical activity). In this case, we can expect that only data coming from little industrialized world regions would have some information value because they would represent physically active people with low body fat. For example, the review of Heath and Carter [10] hinted at remarkably ectomorphic somatotypes of Sudanese Nilotes and Indians (South Asians), contrasting with highly mesomorphic values of the Manus islanders in Melanesia, and endo-mesomorphic physiques of Eskimos (Inuit).

During the last two decades, multiple medicinal studies indirectly assessed differences in muscle devolopment in a more sophisticated way, from the comparison of fat/fat-free mass ratio at a given BMI [11-14]. The results point to a remarkably muscular physiques of Pacific Islanders, followed distantly by US blacks, Caucasian" (mostly US whites/Dutch), Chinese, Southeast Asians (Indonesians, Malays), Indians and Ethiopians. However, the number of studied ethnicities is still insufficient for answering some interesting questions. For example, the tendency towards better muscular development in US blacks (and West Africans in general) in comparison with US whites and other studied Caucasians [15] contrasts with their marginal success in strength-based sports that are usually dominated by (East) Europeans, Central Asians and Near Easterners.

Despite limited data, we think that there exists a surprisingly effective way, how to compare somatotype differences among racial or ethnic groups: via the collection of physical characteristics of elite athletes. The presumption is that Olympic athletes represent the maximal limit of trainability of their native population, and since they usually carry little body fat, their BMI values could serve as a good tool for the comparison of differences in muscle development.

At first glance, this method may not seem meaningful, because it can be influenced by too many variables: the number of nominated athletes, the number of sports in which they compete, specifics of the local sports culture etc. However, it is understandable that all countries will nominate their athletes predominantly to sports, in which they achieve some international success. In theory, these sports should require body types that are very frequent in their population. The opposite will be true in sports, in which they regularly fail, and in some cases, the respective country will have difficulties to even nominate some athletes of international calibre. Moreover, it can be expected that their body build will be inferior to that of their elite rivals. As a result, we could suppose that Olympic teams would mainly consist of athletes, whose physiques are not very distant from the typical physique prevailing in their native population.

An interesting comparison of this sort was already made by Japanese researcher Kin-itsu Hirata at the Olympic games in Tokyo 1964 [16]. Although Hirata knew only age, height and weight of participating Olympians, the average national values of height and weight plotted on a graph demonstrated remarkable regional differences – and mainly in male European samples that were most representative (Figure 1).

Olympians from the western half of Europe were generally lighter than those from the eastern half on the continent. A similar west-to-east trend appeared even in countries from the Mediterranean that were positioned in the height underground. Most notably, the tallest European nations of that time had the tallest Olympic teams, while the shortest European nations (especially from the Mediterranean) had the shortest teams. In the global comparison, Europeans appeared as the tallest, followed by some Oceanic and American countries that mostly have large populations of European ancestry. Countries from the tropical regions of Asia were generally the shortest, which again agrees with the global picture (cf. [17]).

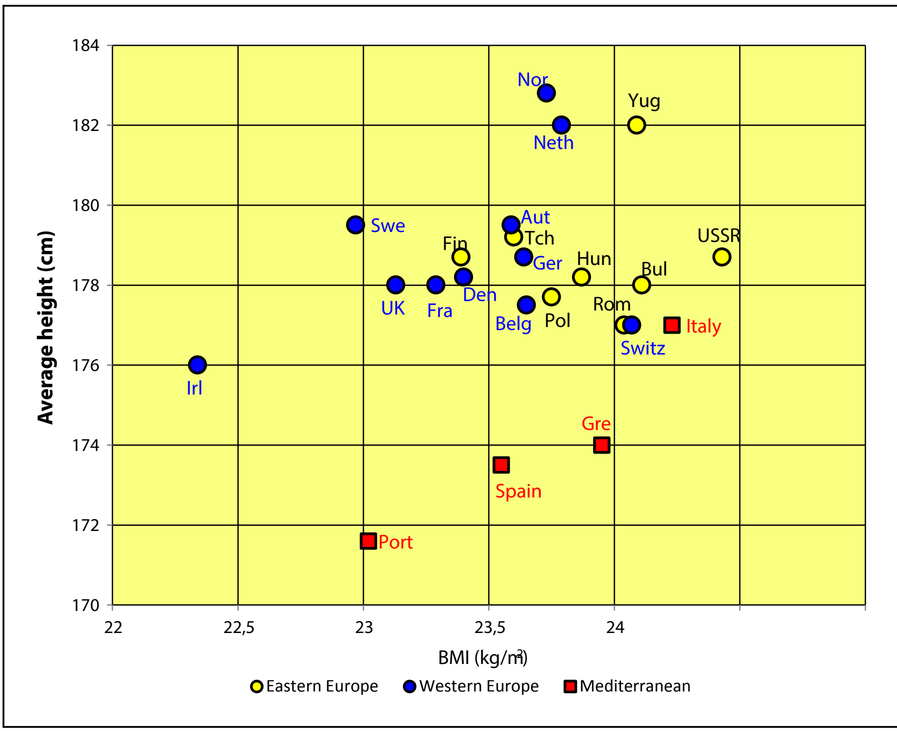


Figure 1 Height and BMI values of male European Olympians in Tokyo 1964 (23 countries).

All Olympians competing for the respective country were included. (After the data of Hirata [16].)

Apparently, the hypothesis outlined in our previous paragraph applied well for height in Hirata's samples: Tall nations nominated tall Olympic teams, because they can successfully compete in height-demanding sports, while short nations struggled to find athletes of similar size and their Olympic average of height was inevitably shorter. Similarly, we could suppose that nations with a gracile body build would find very few – if any – representatives that would be competetive in weightlifting or wrestling, while nations successful in these sports will fail in long distance running or road cycling. In other words, if Olympic data detected objective differences in height, they could also demonstrate ethnic differences in weight (or BMI, respectively).

Considering that the height of Olympic teams was influenced by the spectrum of sports and was consistently higher than in the general population, BMI data could be influenced by the BMI range of Olympic sports as well. Nevertheless, even the relative comparison of national/ethnic means would comfortably serve our purpose. The major problem is the relative lack of data that could support the validity of these observed BMI values. The studies of Deurenberg et al. [11-14] were one of such useful aids, and another important proof would be their historical and geographical consistency.

Therefore, we decided to compare Hirata's data from the Summer Olympic Games in Tokyo 1964 with data from multiple later Summer Olympics (2000-2016) and examine their geographical consistency. Our assumption was that the current level of competition, the number of competing countries as well as the number of Olympic sports is much higher than in Tokyo 1964 (19 sports in Tokyo 1964, 28 sports in Rio 2016) and regional differences in sports abilities should be much better visible. At the same time, it is understandable that the presumed „national physiques" will emerge better in smaller or moderately populous nations, because large countries usually have sufficiently large talent pools to cover the majority of popular sports. The obtained results could subsequently have important implications for national programs of sports selection because they would enable a more economical funding of sports activities in which the respective country has the best chance of international success.

Methods

For the collection of the athletes' basic physical characteristics, we requested data on body height and weight of Olympians from five Summer Olympic Games (2000–2016) from the International Olympic Committee (IOC). These data are part of the Olympedia.org database that was built by independent researchers [18] and is planned to be officially acquisited by the IOC in the near future [19].

The sample of male Olympians included 22,397 individuals. However, these raw data required some editing. First, we excluded Olympians, who competed for a different country than for that in which they were born. Second, we excluded Olympians for which complete data on height and weight were not available. Third, when a range of weight was listed for some athletes, we opted for the mean value. Finally, Olympians competing for Serbia and Montenegro (before the dissolution of this country in 2006), or for independent teams at the Olympics ('Independent Olympians'), such as Kuwait and Russia in Rio 2016, were assigned to the country in which they were born. After these adjustments, 19,969 (89.2%) athletes remained in the dataset.

Table 1. Average height, weight and BMI of 66 male national Olympic teams at the Summer Olympic Games 2000-2016.

Country	***n* *(athletes)***	**Height (cm)**	SD (±)	**Weight (kg)**	SD (±)	**BMI (kg/m^2)**	SD (±)
Albania	17	178,6	10,1	84,0	15,4	26,16	2,79
Algeria	139	177,0	7,2	70,8	13,1	22,50	3,17
Armenia	73	173,6	9,0	76,0	20,8	24,99	5,47
Austria	119	183,4	7,5	78,7	14,2	23,30	3,39
Azerbaijan	72	173,6	8,1	70,9	12,9	23,40	3,22
Bahrain	12	173,8	4,7	68,6	6,2	22,70	1,95
Belarus	213	182,3	10,0	82,4	17,7	24,63	3,86
Belgium	195	182,3	7,1	74,8	9,1	22,46	2,01
Bosnia and Herzegovina	26	189,2	9,2	89,2	15,8	24,89	3,91
Bulgaria	146	181,7	12,0	79,4	15,1	23,93	3,29
Croatia	191	189,7	9,0	90,8	13,3	25,13	2,58
Cyprus	26	182,6	6,8	76,6	9,6	22,94	2,24
Czech Republic	231	185,0	7,7	83,5	14,3	24,31	3,26
Denmark	200	185,4	6,6	81,4	12,3	23,62	2,85
Egypt	271	182,1	10,4	81,9	13,9	24,63	3,35
Estonia	88	187,1	6,9	89,3	16,4	25,45	4,10
Finland	112	183,0	8,3	83,2	16,7	24,77	4,13
France	618	183,1	9,5	78,0	13,3	23,16	2,59
Georgia	103	177,7	8,7	82,7	21,0	25,92	5,02
Germany	735	186,7	9,3	84,0	13,9	23,99	2,82
Greece	268	184,6	9,3	82,3	12,9	24,08	3,03
Hungary	300	185,0	9,1	85,0	16,2	24,67	3,49
Iceland	37	189,4	6,0	91,6	13,8	25,43	2,82
Iran	160	181,3	10,7	82,7	19,5	25,00	4,71
Iraq	52	177,3	7,8	76,3	12,5	24,16	2,78
Ireland	99	183,1	7,2	77,9	12,8	23,17	3,02
Israel	46	179,7	7,4	73,3	11,3	22,62	2,27
Italy	606	183,0	9,2	78,8	12,5	23,46	2,74
Jordan	17	175,5	6,3	73,1	10,5	23,68	2,49
Kazakhstan	208	179,9	9,3	77,5	15,7	23,81	3,64
Kuwait	41	176,5	7,2	74,3	14,6	23,83	4,51
Kyrgyzstan	61	178,0	9,6	76,0	17,3	23,87	4,48
Latvia	80	184,1	7,0	84,9	14,9	25,04	3,99
Lebanon	10	179,8	7,2	78,0	6,0	24,14	1,52
Libya	11	172,5	4,6	67,0	5,4	22,53	1,82
Lithuania	143	189,6	10,9	87,5	16,0	24,19	2,89
Luxembourg	14	186,2	5,6	71,9	6,1	20,75	1,67
Macedonia	12	179,7	3,8	73,8	4,7	22,88	1,82

Malta	11	178,6	5,5	77,3	10,0	24,14	2,28
Moldova	61	177,8	10,1	77,3	18,4	24,22	3,81
Morocco	121	176,3	7,6	67,6	11,4	21,62	2,43
Montenegro	36	191,7	7,3	95,1	9,3	25,92	2,49
Netherlands	372	186,4	8,6	81,4	11,8	23,35	2,53
Norway	89	184,2	7,33	81,8	14,5	24,05	3,57
Poland	449	185,1	9,2	82,9	15,5	24,11	3,56
Portugal	151	179,5	7,3	73,7	10,6	22,81	2,36
Qatar	44	180,1	8,6	76,1	16,7	23,33	4,02
Romania	178	181,5	11,6	80,6	17,8	24,24	3,45
Russia	632	183,7	10,7	81,6	16,6	24,05	3,69
Saudi Arabia	42	174,4	9,0	71,1	11,6	23,32	3,04
Serbia	188	190,9	9,4	87,5	12,3	23,92	2,09
Slovakia	139	183,4	7,1	79,7	11,9	23,62	2,85
Slovenia	137	185,2	8,2	83,8	13,5	24,32	2,81
Spain	547	181,5	9,7	78,0	14,9	23,53	2,97
Sweden	215	185,2	8,1	83,9	13,7	24,37	3,05
Switzerland	184	181,6	7,8	76,6	10,5	23,16	2,09
Syria	18	177,3	6,8	80,8	21,5	25,71	6,54
Tajikistan	19	179,1	8,2	80,7	18,4	25,02	4,80
Tunisia	149	184,6	10,3	82,2	15,8	23,99	3,65
Turkey	135	176,2	8,9	76,4	19,3	24,37	4,52
Turkmenistan	20	179,2	9,7	80,5	19,1	24,97	4,91
UAE	34	175,2	4,5	71,2	7,3	23,25	2,69
Ukraine	350	181,6	9,6	79,3	17,2	23,90	3,85
United Kingdom	600	184,1	8,5	80,8	13,5	23,75	2,87
Uzbekistan	150	178,5	9,2	77,9	17,2	24,25	3,97
Yemen	11	170,8	6,8	63,6	6,5	21,78	1,51

Subsequently, we computed averages of BMI in each athlete, and computed averages of height, weight and BMI for each national Olympic team having at least 10 representatives at these five Olympics. In the current paper, we will present results for 66 countries from Europe, North Africa, the Near East and Central Asia (Table 1), which roughly corresponds with the traditional anthropological classification of 'Caucasians'. In order to better visualize geographical differences in our graphic comparisons, the samples were divided into individual regions. In addition, averages of medal winners in 20 athletic disciplines from the same Olympics were computed.

Results

The graphical comparison of the Olympic teams is displayed in Figure 2. For better clarity and the elimination of outliers, only Olympic teams having at least 20 athletes were included. We can see that the west-to-east trend in Europe and North Africa has remained the same, although BMIs of 20 European countries from Tokyo 1964 and the five Olympics (2000-2016) do not correlate significantly (r=0.20, p=0.41). A better result would probably be possible, if we compared mean values from more past Olympics.

Still, due to the disintegration of the former Communist bloc, a more detailed geographical structure is emerging. More concretely, the area with the tallest and heaviest statures is dominated by Iceland and countries from the Baltic region and the former Yugoslavia. These national averages are the closest to physiques that are typical of heavy athletics (BMI 26+ kg/m^2, height 188+ cm: javelin, discus, hammer, shot put). Countries from Western Europe and North Africa are positioned close to running events. At the same time, the statures of North African teams are shorter and closer to long distances, whereas West European teams are taller and closer to the 110 m/400 m hurdles and the 400 m flat. In addition, West European Olympians also stand in the proximity of jumping events.

Short sprints (100 m, 200 m) are positioned in the middle of the graph, roughly in the area of the meridian belt of Central Europe. Interestingly, countries from the northern part of the Near East and from Central Asia also tend to have above-average values of BMI, but due to their short stature, they are quite distant from the physiques that are characteristic for heavy athletics. Arabic-speaking countries of the Near East (including Israel) have similar statures, but lower BMI values. In summary, teams from Central Asia and the Near East have an unfavourable body build for the participation in athletic events.

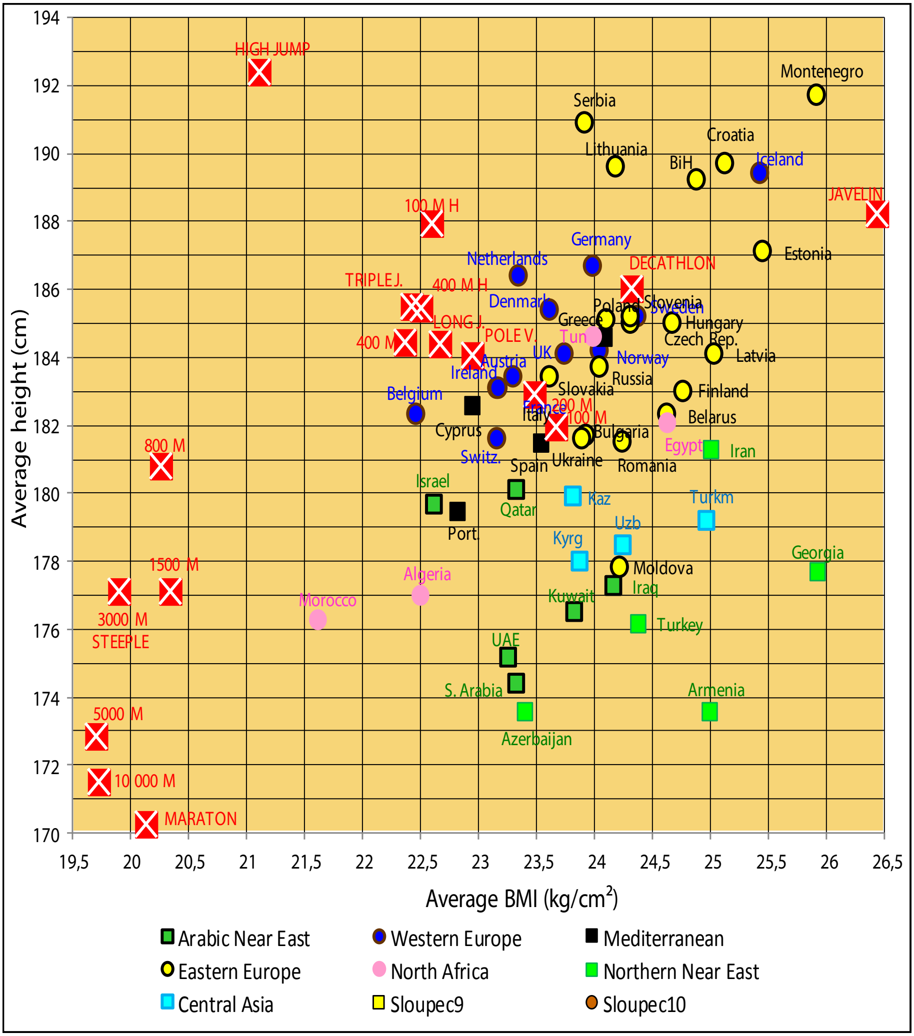


Figure 2. Average height and BMI of Olympic teams from Europe and neighbouring regions (55 teams with at least ≥20 Olympians).

The averages of medal winners in athletic events (SOG 2000-2016) is included for an additional comparison.

Figure 3 expresses geographical differences in BMI. The highest values are typical of Northern Europe (Iceland and the Baltic region), the Western Balkans and the Near East up to Central Asia (Tajikistan). On the other hand, BMI values decrease in the (south) western and southern direction.

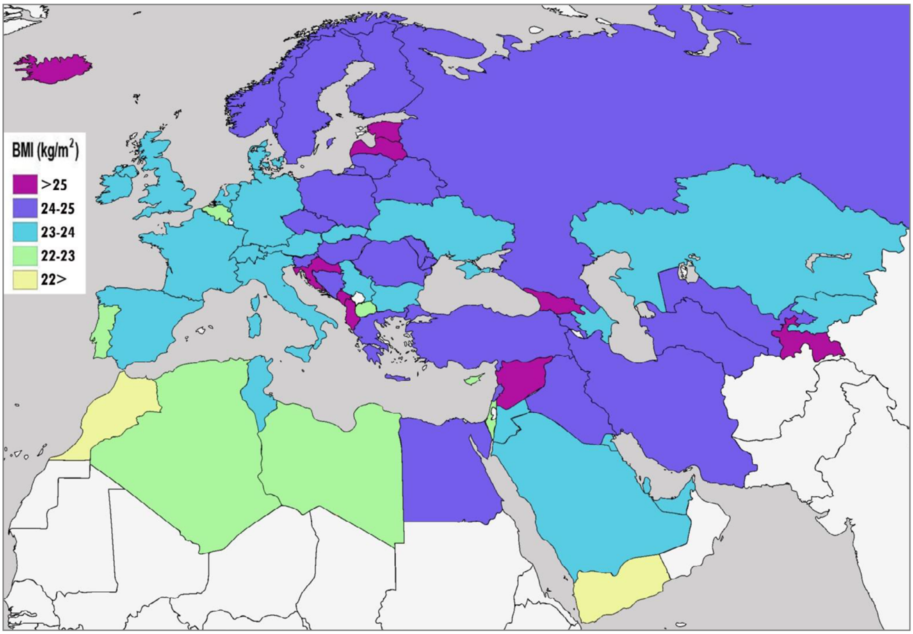
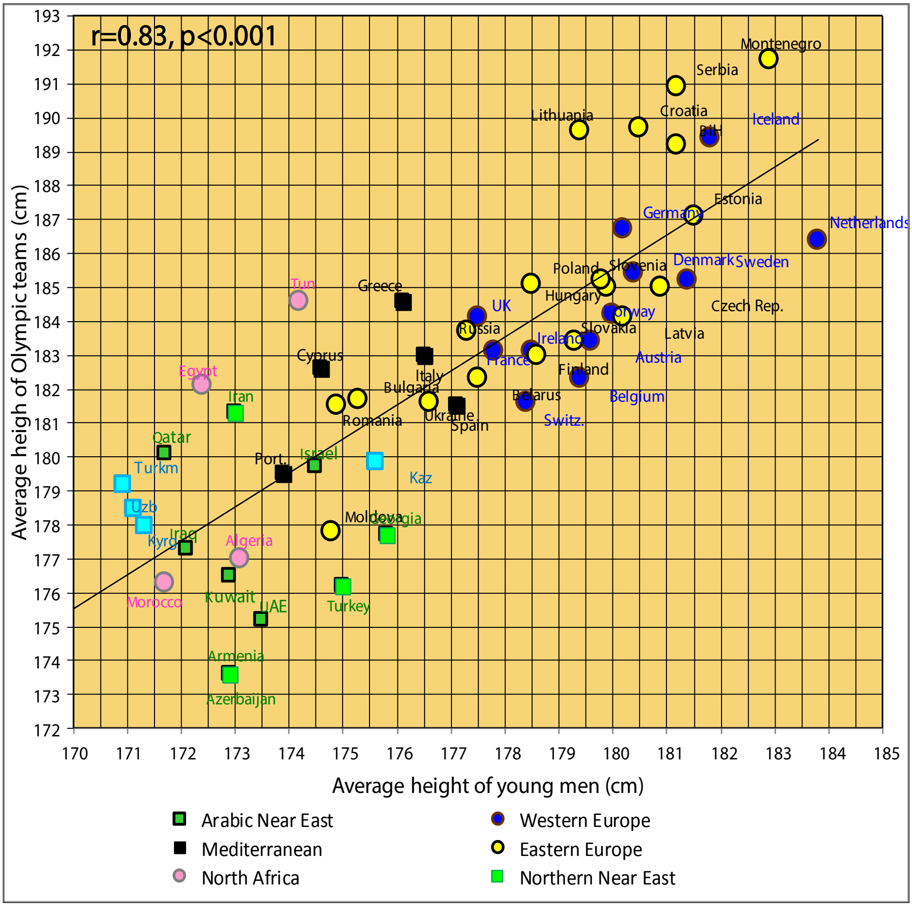


Figure 3. Geographical comparison of BMI values in male Olympic teams.

Using our updated dataset of the average height in young males [20], we can also compare the mutual relationship between the height of 55 Olympic teams and the height of their native populations (Figure 4). As expected, the correlation is very high ($r=0.83$, $p<0.001$). When the complete sample of 66 countries is used, the result is even more robust ($r=0.85$, $p<0.001$).

Figure 4. Relationship between the average height of young males and the average height of Olympic teams from Europe and neighbouring regions (55 teams with at least ≥20 Olympians).



Discussion

The present study is the first stage of our future project that will examine geographical relationships among the physique of Olympic teams from 146 countries. Although we did not find a significant correlation between BMI values from Tokyo 1964 and our mean from the years 2000-2016, it is apparent that BMIs of Olympic teams have a characteristic geographical pattern. While teams from Western Europe, the western part of North Africa and from the majority of Arab countries tend to have a rather gracile body build, Olympians from Eastern Europe and the mountainous ranges of the Near East and Central Asia are robust. At the same time, we can observe marked differences in height even within this division.

The geographical tendencies documented in the present study have a sound scientific explanation and relate to the human adaptations to climate [21-23]. In general, these adaptations follow the Allen's rule stating that animals living in colder climates usually have shorter limbs and stockier, wider body than genetically related animals from warmer climates. These characteristics lead to decrease of body surface area and prevent excessive heat losses. In warmer climates, the opposite effect is necessary, because animals are endangered by overheating, and that's the reason, why longer limbs and a more slender constitution are beneficial. Another biological rule related to climate, the Bergmann's rule, describes a tendency towards larger body size in colder climates. Again, larger bodied animals experience relatively smaller heat losses, because they have a more favourable surface area/body volume ratio and can better „keep up" with heat losses. The west-to-east trend of increasing BMI values mirrors the decrease of winter temperatures and in our future work, we plan to compare the physique of Olympic teams with climatic conditions in their native countries.

The tallest statures combined with remarkable physical robuscity are typical of Iceland, the Baltic region and the area of the Dinaric Alps in the Western Balkans. The unusual tallness of people from the former Yugoslavia was addressed by our previous paper [24], in which we demonstrated that some regions of Herzegovina are characterized by men's averages over 183 cm. The results of our colleagues from Montenegro [25] and our unpublished data from Dalmatia show that there are regions, where average male height increases over 185 cm. The reasons of this exceptional height appear to be genetic, and because the current level of nutrition in the former Yugoslavia is not optimal, we can expect that the positive secular trend of height increase will continue. In fact, it can be estimated that under optimal conditions, the maximum height of Dinaric highlanders can reach 190 cm [24]. Because the majority of Olympic sports requires tall statures above 180 cm, we can expect that in the future, the region of the Western Balkans will further strengthen its position as the richest source of sports talent (per capita) in the world. Unfortunately, the local system of sports talent education is still directed towards team sports, in which physical predispositions are not as important as in individual sports.

Our preliminary unpublished data indicate that the geographical differences in stature and BMI would be further highlighted, if we used the means of Olympic medal winners. This is quite logical because sports, in which these athletes gain medals, are just those for which their native countries have the largest talent pool. Identifying such "ideal sports" for each country would certainly economize talent selection.

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METHODICAL MODEL FOR CORRECTION OF COMMON MISTAKE IN THE BASIC SKI TURN PERFORMANCE

Kuna Danijela[1], Božić Igor[2], Očić Mateja[3]
[1]Faculty of Kinesiology, University of Split, Croatia, [2]University of Banja Luka, Faculty of Physical Education and Sport, Bosnia and Herzegovina, [3]University in Zagreb, Faculty of Kinesiology, Croatia

Abstract

Handling of characteristic errors is an integral part of the process of adoption of skiing techniques. The expert instructions help alpine skiers to train, so it is important to form and refine expert models for teaching and correction of characteristic mistakes. The aim of this research was to define the methodical exercises for correcting the error interfering with performance of basic ski turn. The respondent sample consisted of 20 skiing experts aged 25 to 45 years. They were interviewed by email on the typical errors which most often occur during performance of basic ski turn and then asked to select three most important ones on a scale ranging from 1 to 3. Following, the experts defined the methodical model of exercises for correcting the error leaning back forced turn (LBFT), which according to their opinion, interferes the most with performance of basic ski turn. Moreover, on a scale ranging from 1 to 5, they graded methodical exercises with potential to be used for correction of this error. In accordance with the objective set by the study a nonparametric chi - square test (c2) was used. Tested was statistical significance of the differences (p) in the frequency of the expert evaluation of the three errors interfering the most with proper performance, and in the evaluation of the five methodical exercises which, in the formed expert model, have the highest significance in the correction of the LBFT error. There was statistically significant difference between the most efficient methodical exercises for correcting the LBFT error during basic ski turn (c2= 14; p= 0,12). Obtained results help in defining fundamental methodology of perfecting basic ski turn. Future research should concentrate on application of defined model during different conditions and its improvement.

***Key words**: Expert evaluation, alpine skiing, methodical exercises, basic ski school.*

Introduction

Physical activity preferences are defined by different factors, among which the activity curriculum contents, teacher/instructor's behavior, the facilities in which the activity is conducted and work climate play an important role in activity selection and in persistence in it (Agbuga, Xiang, & McBride, 2013). The lesson represents the basic form of organising the instructive-educational process in order to acquire the ski technique (Federolf et al. 2012). In teaching, mastering and practicing alpine skiing, learning on the basis of a model is most common. For years, ski schools focused their instructions on teaching a „perfect“ skiing technique. Classic teaching still exists, but further options such as new school, freeriding, and skiguidling are now available. The basic technique of alpine skiing include an assembly of technical procedure of variable complexity whose methodic sequencing engenders the acquisition of specific motility skills which allow snow sliding for education or recreation purposes. The structural mobility of the lesson, as well as its degree of adaptability to the concrete conditions ensures its efficiency. Two main ways of basic teaching are used in terms of traditional methodic orientation nationally and internationally. These two directions distinguish themselves by means of the mechanism of leading the skis and turning: the direct way and the indirect way. For those with less developed basic motility skills, the indirect way is recommended. The indirect way has at its foundation the unparallel ski technique and alternative (successive) transfer of general centre of gravity, having as technical objective the acquisition of adaptability skills on any kind of surface. For those with a higher level of motility skills, the direct way is recommended. The direct way resides in a basic execution technique with parallel skis and simultaneous bray centre transfer (Murovec, 2006). All the mentioned factors result from specific divisions and formations of different skiing school programme models which enables and accelerates the process of acquiring skiing knowledge (Anderson, 2007; Lešnik & Žvan 2010). The basis of the programme facilitates the adoption of various techniques of alpine skiing and secures the gradual progress of skiing learning. In relation to the mentioned and with the aim of rational performance and lower energy consumption, the skiing elements and methodological exercises should succeed one another in a logical methodological order. High quality and professional help of teachers or trainers is the key factor in the process of acquiring and perfecting skiing knowledge. In order to secure adequate teaching, skiing teacher or trainer should have a high level of skiing knowledge and skills, and also understand methodologic and didactic principles of training process and the basis of psychological approach of working with people.

The current focus on technique has meant that different countries and ski schools have adopted distinctive technique-based teaching programs under the assumption that a specific technique developed is the most effective (Žvan et al. 2015). We sampled the ideas of the ski coaches from different countries to ascertain how the basic turn was taught to learners. Several studies dealing with the formation of expert models for training alpine skiers and the hierarchical classification of the said (Kuna et al. 2014, 2015). In order to establish further methodical settings arose the main objective of this study, which is the formation of an expert model of the most important methodical exercises for correcting the error which most interferes with performing basic ski turn.

Methods

The respondent sample consisted of 20 national demonstrators aged 25 to 45. Among these, there were 8 Croatian, 6 Slovenian, and 6 Bosnian national demonstrators selected as the top skiing experts on the basis of their skiing knowledge, and they voluntarily agreed to take part in the study.

By means of email and coordinated by the paper author, the experts first defined the most common errors in performing basic ski turn and then, on a scale from 1 to 3 (1- smallest error, 2 – medium error, 3 – great error), selected the three errors which most disturpts proper performance of the basic ski turn. Following this, the experts defined a methodical model of the exercises for correcting the error which most disturpts proper performance of basic ski turn and, on a scale from 1 to 5, graded these 5 methodical exercises based on their significance in the correction of this error. The experts assigned the methodical exercises one of the following values: 1 – very small significance, 2 – small significance, 3 – medium significance, 4 – high significance, and 5 – very high significance.

The expert model of typical errors encompassed six mistakes, namely: LBFT (leaning back forced turn using the torso), IPS (improper position of skis), WTP (wrong timing performance), ILOS (insufficient load on outside skis), PDS (performance downhill sloping), PFK (passive function of the knee).

Samples of variables for the most important methodical exercise for correction of error *LBFT (leaning back* forced turn using the torso*),* which most interferes with performing the basic ski turn, included twelve methodical exercises: *BTA (basic turn airplanes), SKNDSP (downhill sloping with overstep to turn), TTHAS (turn towards the hill with active skies), TTHTP (turn towards hill and take off into plow), WBT (wreaths basic turn), BTC (basic turn with clap), UAFB (the upper arm in front of the body, the lower on the hook), ISBN (inner stick behind the neck while the external draw in the snow), BTBT (basic turn behind the teacher), SPE (ski poles extended), BTRIS (basic turn with rising inner skies), SBN (sticks behind neck).*

In accordance with the objective set in this study, i.e. forming an expert model of the most significant methodical exercises for the correction of error that most interferes with performing the basic ski turn, a nonparametric chi-square test ($\chi 2$) was used. We tested the statistical significance of the differences (p) in the frequency of the expert evaluation of three errors that most interfere with its proper performance, and in the evaluation of five methodical exercises which in the formed expert model have the highest significance in the correction of *LBFT* error.

Results and Discussion

Based on the obtained values of testing the frequency of expert evaluation of three errors that most disturpts proper performance of the basic ski turn, it was observed that there was no statistically significant difference between them (*Table 1*).

Table 1. Evaluation of three errors that most disturpts proper performance of the basic ski turn. The observed frequency of an expert evaluation of the most common errors (OF), the expected frequency of the expert evaluation of the most interference errors (EF), the value of chi-square test ($\chi 2$) *and the corresponding level of significance (p).*

Expert model of the typical errors of basic ski turn	OF	EF
LBFT	15	10
IPS	5	10
WTP	13	10
ILOS	12	10
ISPK	9	10
PKF	6	10
	$\chi 2 = 8,00$ $p = 0,16$	

In the expert evaluation, *LBFT (leaning back forced turn)* error has the highest frequency of occurrence in performance of the basic ski turn. A large number of skiing beginners, due to both fear and their desire to gain control over the speed of the skis when moving downhill, shift the centre of the gravity of their body backwards (Kuna et al. 2017). Due to insufficient movements forwards and towards the centre of the turn, the skier's tilting their torso towards the slope, leaning back disables establishing the balance on the outside ski body lags behind the skis which starts accelerating when moving downhill and it most often results in uncontrolled changes in the movement direction and in losing the balance position when performing the basic ski turn. The second most frequent error, typical for performing the basic ski turn is the WTP (wrong timing performance) where the skier on the timing of performance make mistakes. The third most frequent error is ILOS (insufficient load on outside skis) causing the skier to slide uncontrollably and to fail to complete the turn perpendicular to the fall line.

In *Table 2* there is expert model and evaluation of the most efficiency methodical exercises for correcting the *LBFT* error typical of performing basic ski turn. Based on the obtained values of the chi-square test ($\chi 2$) and the corresponding level of significance (p), there was statistically significant difference between them ($\chi 2 = 14$; $p = 0{,}12$).

Table 2. Evaluation of the most efficient methodical exercises for correcting LBFT error, typical for performing the basic ski turn. The observed frequency of an expert evaluation of the most efficient methodical exercises (OF), the expected frequency of efficient methodical exercises (EF), the value of chi-square test (c2) and the corresponding level of significance (p).

Methodical exercises for correcting the *LBFT* error	OF	EF
BTA	8	5
SKNDSP	2	5
TTHAS	3	5
TTHTP	3	5
WBT	4	5
BTC	9	5
UAFB	2	5
ISBN	4	5
BTBT	7	5
SPE	10	5
BTRIS	2	5
SBN	7	5
	$\chi 2 = 14{,}00$ $p = 0{,}12$	

By analysing the results obtained by forming the expert model of the most effective exercises for correcting the typical *LBFT* error for performing the basic ski turn, it can be observed that *SPFB (ski poles in front of body)* exercises has the highest efficiency in correcting the typical *LBFT* error. This is an exercise that has multiple values in correcting various errors. A skier learns the basic ski turn by holding the ski poles perpendicularly in extension. The skier focuses on establishing the central position on skis more easily, developing a sense of regular skis pressure control and coordination of skiing movement.

The second exercise which has the highest efficiency in correcting the said error is *BTC (basic turn with clap)* which enables the skier to put the fists of both hands on knees, pushing them towards the turn, in the phase of an open turn towards the hill, facilitating circular, vertical and lateral knee movements, and more efficiently lowering the body mass centre. By plowing the inner ski, the skier goes from low to high skiing position, simultaneously performing a clap with both hands that are lifted above and in front of the head, what facilitates take off and timely passing of the skis to the following turn enables where the skier to put the fists of both hands on his knees, pushing them towards the turn, in the phase of open turn towards the hill, what facilitates circular, vertical and lateral knee movement, more efficiently lowering the body mass centre. The third most important exercise in correcting *LBFT* error is *BTA (basic turn airplanes)* - the skier to perform the basic turn by imitating airplane. During the parallel turn towards the hill, skier lowers his outer arm towards the ski, while the inner arm is being lifted up. The high value of this methodological exercise is due to better achievement of balance and pressure on the outer ski during performance of turn towards the hill, what facilitates obtaining plow position and passing into the new turn. Fourth most important exercises are *SPN (ski poles on neck)* – the basic turn by holding the parallel ski poles on shoulders, by pushing the outer shoulder down the hill during the open turn towards the hill performance, with the aim of achieving better balance and outer ski burdening and *BTBT (basic turn behind the teacher)* where the skier performs basic ski turn behind the teacher.

Discussion and Conclusion

Honed by years of experience and reflection, expert sport coaches have an extensive foundation of declarative (knowing) and procedural (doing) knowledge which is highly specialised (Nash & Collins, 2006). Important role in learning alpine skiing plays a model i.e. method of alpine ski learning, in addition to capacity and skill of ski beginner and ski surrounding (Lewandowski, 2006). Different models that were used in the process of teaching alpine skiers result various achievements (Cigrovski et al. 2010). Consequently to identify dynamic informational constraints, which are interwoven with individual and task constraints, coaches' experiential knowledge provides a complementary source to support empirical understanding of performance in sport (Greenwood et al. 2012). Integration of experiential knowledge of expert coaches with theoretically driven empirical knowledge represents a promising avenue to drive future applied science research and pedagogical practice (Greenwood et al. 2014). Our investigation proved the importance of Expert coaches' experiential knowledge revealed multiple information sources which may constrain performance adaptations in such locomotor pointing tasks. In addition to the general review of the obtained results leads towards the conclusion that the obtained expertise generally enables a relatively higher quality of alpine skiers teaching process planning. Implementation of our results into future an empirical verification in situational conditions on different aged students of skiing schools everyday practice would contribute to greater methodical instructions for future teaching the basic ski turn to skiing instructors of various expertise levels. To determine more precise settings is necessary to implement in the future an empirical verification in situational conditions on different aged students of skiing schools.

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Correspondence to:

Danijela Kuna, PhD. University of Split Faculty of Kinesiology
Teslina 6, 21000 Split, Croatia
Tel: 00385 (098) 1711997 E-mail: danijela.kuna@gmail.com

THE IMPACT OF EXERCISES WITH A REACTION BALL ON THE EYE-HAND COORDINATION OF BASKETBALL PLAYERS. PILOT STUDY

Lenik Paweł, Przednowek Krzysztof, Śliż Maciej, Bobula Gabriel, Lenik Justyna
University of Rzeszow, Faculty of Physical Education, Rzeszow, Poland

Abstract

Purpose: Eye-hand coordination plays a significant role in performing movement combinations and greatly influences the reduction of reaction time. The aim of the study was to analyze the impact of movement exercises using a reaction ball on the level of selected coordination skills in male basketball players.

Methods: The study was conducted on 13 basketball players aged 20 ± 0.9 years (height 185 ± 6.1 cm, weight 81.8 ± 9.6 kg), who were randomly divided into two groups. The first group (6 subjects) performed specialized exercises using a reaction ball while the second group (7 subjects) had standard basketball training exercises. The experiment was conducted over a period of nine weeks and was conducted twice a week in the beginning of each training session. Each set of exercises lasted no longer than 8 minutes. A reaction ball (weight - 5.6 ounces, dimensions 3 x 3 x 3 inches) was used in the experiment. In both groups, two measurements of eye-hand coordination were carried out (at the beginning and end of the experiment) using the Spatial Anticipation Test (SPANT) on the Test 2 Drive computer system.

Results: The performed analysis demonstrated that the group subjected to specialized training had reduced reaction and motor times. The reaction ball tests showed that after training with the ball, the mean level of successful catching attempts increased, while, simultaneously, the time of individual attempts decreased.

Conclusions: The obtained results indicate that the exercises used in the study can significantly support the development of eye-hand coordination, which directly translates into technical superiority and movement efficiency.

Key words: *Reaction time, basketball, reaction ball, eye-hand coordination*

Introduction

In many sports, the players are required to perform specific activities which require physical exertion of variable intensity. At the same time, the performed motor activities must be executed precisely and as quickly as possible. Thus, one may say that high level skills in recognizing and processing information and generating movement produce better results. This is how the feedback system works [Crawford et al., 2004]. This thesis has been confirmed in studies that proved that movement is initiated with a retinal image and ends with muscle stimulus [Batista et al., 1999]. Thus, creating a situation in which the eye is repeatedly exposed to external stimuli results in reaction time reduction. On the other hand, however, prolonged nervous system load by effort with repeated repetitive stimuli causes nervous system fatigue. Gandevia presented results suggesting that during fatigue efforts, focal lesions in excitability of the cerebral cortex and inhibition based on electromyographic (EMG) records were revealed. The researcher suggestion is also Human fatigue is not simply muscle [Gandevia, 2001].

Combat sports such as karate or taekwondo are good examples of activities in which the reaction time is a key element leading to victory. Fast application of the appropriate technique is the effect of visual evaluation of the opponent's movement [Chaabène et al., 2012]. It is somewhat different in team sports where more aspects affect the final success. That means that team sports have a complex structure and require a multi-faceted approach. Studies show that the ability to react quickly and control movements, even when you are tired, is an important factor in gaining advantage over your rival [Chmura et al., 1994]. It also turns out that the level of training significantly influences reaction time because advanced athletes achieve better results than beginners [Barcelos et al., 2009]. The type of exercise is imperative as well. Intriguing observations were made in an experiment evaluating the reaction time after intensive static stretching. The study revealed that a 5-minute static warm-up with 45 seconds of stretching and 15 second breaks resulted in worsening of reaction time [Behm et al., 2004].

Chatzopoulos found also that there are no effect of the stretching protocols on reaction time. According to his results, warm up before exercise do not have improvement on reaction time. The same conlusions about an influence of warm-up on reaction time had other researchers [Alpkaya et. al. 2007, Perrier et. al. 2011, Chatzopoulos et. al. 2014]. Perrier et al. also compared the effects of a warm-up with static and dynamic stretching on countermovement jump (CMJ) height and reaction time. After an analysis, found that reaction time after warm up have no significant effect on it.

Another noteworthy study was the one performed on a group of 167 basketball, football and volleyball players. After exertion of submaximal intensity, there was reaction time reduction, however, the number of decision-making errors increased significantly. It can therefore be concluded that the players made decisions faster but accuracy was compromised [Thomson et al., 2009].

These studies showed that eye-hand coordination is a skill that we can perfect by means of appropriate exercises. Multiple repetitions of activities that force an athlete to recognize and process information, follow a fast-moving object and react to changing conditions lead to improvement in reaction time.

The main aim of the study was to evaluate the influence of exercises using reaction balls on selected aspects of eye-hand coordination. To verify the results, the experiment was conducted with a group of basketball players.

Figure 1. Reaction Ball

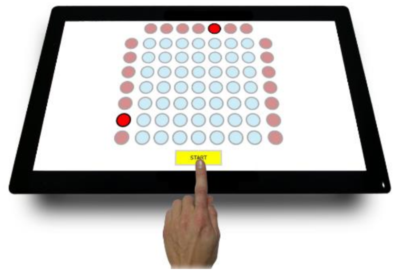

Figure 2. Drive - Spatial Anticipation Test

Methods

13 men aged 20 ± 0.9 years were analyzed. The somatic build of the study subjects was characterized using basic somatic features (body height: 185 ± 6.1 cm; body weight: 81.8 ± 9.6 kg). The study group consisted of basketball players divided into 2 groups. The training group - 6 players - and control group - 7 players. The right hand was dominant in all players. The study lasted 9 weeks. During the experiment, the study group performed an 8-minute set of exercises twice a week. The time and type of exercises were established on the basis of studies by Kashibara and Nakahara, who found that physical exertion lasting longer than 8 minutes did not help in reaction time improvement and that the training intensity should not be too high [Kashihara, Nakahara, 2005]. Thus, the exercises were performed before the proper warm-up.

An important factor conditioning the long duration of the experiment was the results of research suggesting that prolonged stimulation of the nervous system with physical effort causes fatigue. It affects proprioception, tremor and posture control [Gandevia, SC 2001].

Another factor influencing on 9-week protocol was hypothesis about adaptation of the nervous system to emerging stimuli and suggests after unsuccessful movements. Participants formulates hypotheses regarding probable causes of error and the required motor adaptations necessary to eliminate them. Therefore, times and movement should be longer after mistakes, in relation to successful movements. This hypothesis was tested using golfing skills [Lam WK et al. 2010].

The players trained in pairs and SKLZ reaction balls were used in training (weight - 5.6 ounces; dimensions 3 x 3 x 3 inches) SKLZ reaction ball (Fig. 1) (http://global.sklz.com/pl-en/products/performance/agility/reaction-ball) was used according to the guidelines and in conditions provided by the manufacturer. The set of exercises used in the experiment:

1. Catching the ball with both hands after bouncing it off the floor, with a 1-meter distance between players.
2. Catching the ball with the right hand after bouncing it off the floor, with a 1-meter distance between players.
3. Catching the ball with the left hand after bouncing it off the floor, with a 1-meter distance between the players.
4. Catching the ball with both hands after bouncing it off the floor, with a 3-meter distance between the players.
5. Catching the ball with the right hand after bouncing it off the floor, with a 3-meter distance between the players.
6. Catching the ball with the left hand after bouncing it off the floor, with a 3-meter distance between the players.
7. Catching the ball with both hands after bouncing it off the floor, with a 5-meter distance between the players.
8. Catching the ball with the right hand after bouncing it off the floor, with a 5-meter distance between the players.
9. Catching the ball with the left hand after bouncing it off the floor, with a 5-meter distance between the players.

Before starting the experiment and after its completion, the players' reaction times were tested using the Test2Drive tool [Tarnowski, 2016]. The tool evaluates eye-hand coordination and the ability to plan movement in a situation requiring spatial orientation. The subject's task was to select and press one of two fields identical to the one displayed on the screen. A Iiyama Pro Lite T2435MSC Full HD touchscreen monitor was used in the study. Using a touchscreen monitor facilitates replacement of complex, traditional equipment with a computer system while keeping the necessary level of objectivity and measurement standardisation. Table 1 presents a detailed description of the test.

The frequency and duration of the exercises during our experiment on basketball players was design according Kashimira and Nakahara 2005 experiment. Kashimira and Nakahara found that physical exertion lasting longer than 8 minutes did not help in reaction time improvement and that the training intensity should not be too high [Kashihara, Nakahara, 2005]. Nine weeks experiment was used also in other experiments [Osterås et. al. 2002, Balkó et. al. 2017].

A test was designed for the experiment, in which the time(s) of catching the ball after one bounce off the floor was measured. The test involved dropping the SKLZ ball by the testing player to a designated area of 50x50 cm and catching it as fast as possible by the tested player. The height from which the ball was dropped was marked with laser pointer (set at 130 cm) indicating the middle of the ball. Each player had 10 tries. If the ball bounced twice in the designated area or outside it, the try was terminated and regarded as a failure. The test was performed twice - before and after the experiment.

Results

The study of the influence of the exercises with the reaction ball on reaction time involved analysis of tests performed with the ball and of the Test2Drive system SPANT test results. First of all, the reaction ball test result changes occurring under the influence of the applied training were analyzed (Fig. 3). The performed studies show that the training group had a number of successful catches about one try higher (1.33) than before and there were no significant changes in the control group (0.14) (Tab. 1). When analyzing mean catching times, it was found that the training group had a significant reduction (0.11ms, $p<0.05$), while in the control group were on the same level in measurements 1 and 2. The first group of the parameters analyzed by SPANT test are the subject response rates (Fig. 4). The performed studies show that in the second measurement the number of correct answers increased in both groups (for T by about 6%; for C by about 1%). In both cases, the results were not statistically significant. The rate of incorrect answers decreased slightly in both groups. The last percentage parameter describes the out-of-range responses. The rate of such responses decreased in the training group by about 3% and increased in the control group by about 3% (Tab. 2). Another group of parameters in the SPANT test are time parameters (Fig. 5). Test time, reaction times (mean, median, minimum and maximum) and motor time are evaluated (Tab. 2). The analysis showed that both groups had shorter test time in the second measurement, about 0.71s in T group and 0.62s in C group. In both groups the changes and the differences in test time were statistically significant ($p<0.05$) (Tab. 1).

Table 1. The mean values and intergroup difference

Test	Measurement 1				Measurement 2				Training		Control	
	T	C	T - C	p	T	C	T - C	P	M2 - M1	p	M2 - M1	P
Ball (number of attempts) [n]	7,33	7,86	-0,52	0,101	8,67	8,00	0,67	0,946	1,33	0,068	0,14	0,715
Ball (mean time) [s]	0,82	0,75	0,07	0,093	0,70	0,74	-0,03	0,701	-0,11	0,028	-0,01	0,735
Correct Answers [%]	87,5	84,3	3,21	0,165	93,3	85,7	7,62	0,846	5,83	0,225	1,43	0,590
Wrong Answers [%]	5,83	5,71	0,12	0,348	3,33	1,43	1,90	0,545	-2,50	0,273	-4,29	0,180
Answers Out of Range [%]	6,67	10,0	-3,33	0,261	3,33	12,9	-9,52	0,558	-3,33	0,35	2,86	0,500
Execution Time [s]	2,01	1,97	0,04	0,045	1,30	1,35	-0,05	0,012	-0,71	0,046	-0,62	0,018
Median Time of Movement [ms]	227	299	-72,2	0,936	228	283	-54,6	0,608	1,33	0,834	-16,3	0,398
Median Time of Reaction [ms]	647	659	-11,9	0,471	597	651	-54,6	0,402	-49,5	0,249	-6,86	0,753
Mean Time of Reaction [ms]	661	664	-3,21	0,689	628	679	-51,3	0,898	-32,8	0,249	15,3	0,398
Minimum Time of Reaction [ms]	499	509	-10,6	0,872	508	511	-3,60	0,949	9,33	0,529	2,29	0,933
Maximal Time of Reaction [ms]	1138	1175	-37,1	0,378	964	1192	-228	1,000	-174	0,345	16,7	0,866

T - training group; C - control group; T-C - the difference between training and control group; M1- first measurement; M2 - second measurement; M2-M1 - the difference between second and first measurement.

The median motor time did not demonstrate any clear changes under the influence of the applied exercises. There was a slight increase in the training group (1.3ms) and a slight decrease in the control group (-16.3ms). Significant influence of the applied exercises was observed in case of mean and median reaction time parameter changes. Mean reaction time decreased by about 33ms in the training group and increased by about 15ms in the control group. A similar correlation was found in the median reaction time, which improved by as much as 50ms in the training group. Likewise, the minimum time increased in the training group and the maximum time decreased (Fig. 5). The test result improvement in the control group may be explained by the phenomenon of test learning. The subjects performing the same test for the second time obtain slightly better results because they are familiar with the test procedure.

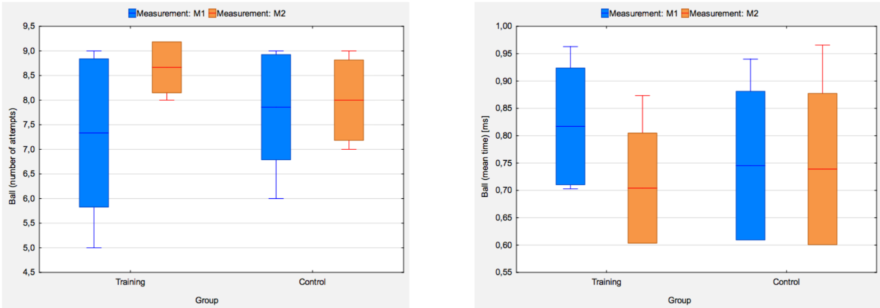

Figure 3. Reaction Ball Test - the number of attempts and average grip time

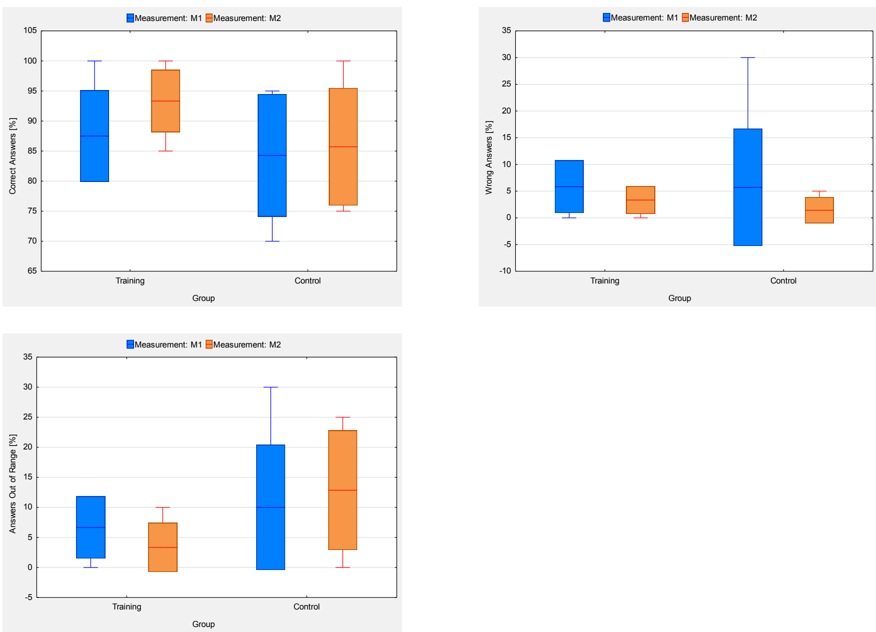

Figure 4. Spatial Anticipation Test - percentage parameter

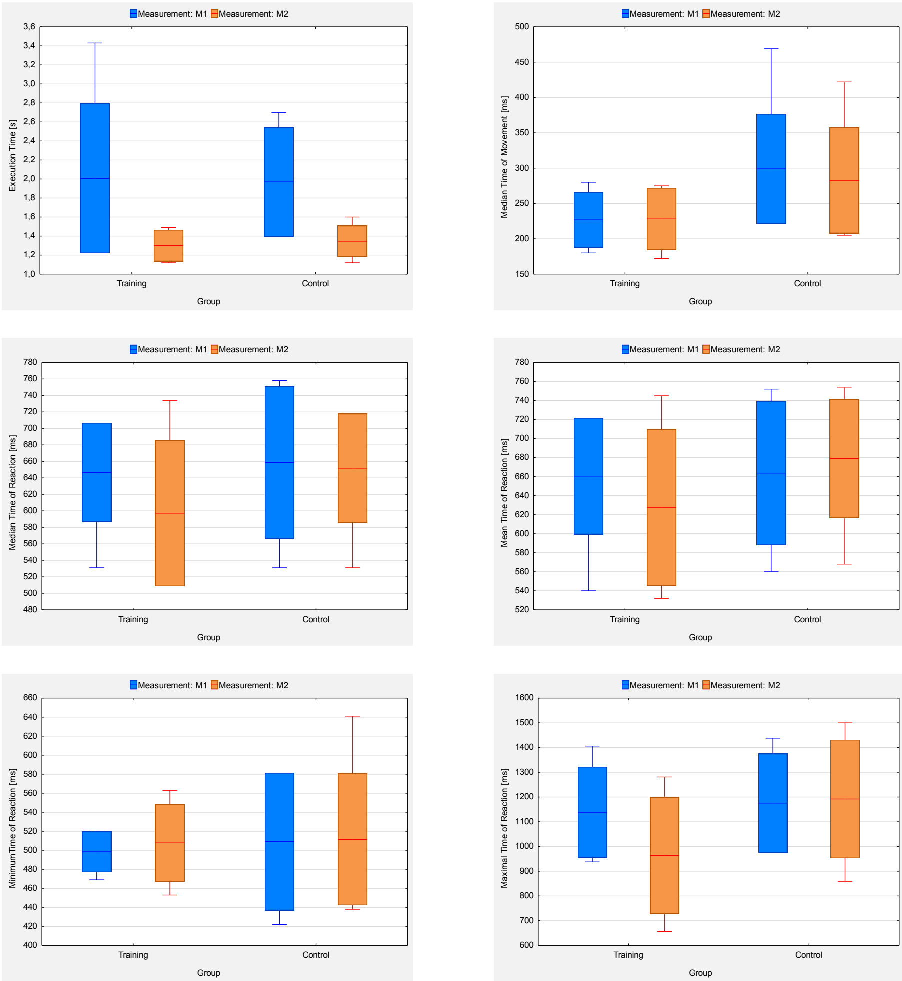

Figure 5. Spatial Anticipation Test - time parameters

Discussion

Eye-hand coordination is a skill that can be trained and may contribute to increasing the player's motor potential. [Vine, Wilson, 2011]. It can also influence movement efficiency and thus improve the player's performance in competitive circumstances. It should be pointed out that the objectives of the performed experiment were: improvement of eye-hand coordination and reduction of reaction time. The results indicate that certain exercises can significantly help in shaping the eye-hand coordination. The obtained results align with the results acquired by researchers who proved that the planned hand movements are supported by vision. There is a close link between eye-hand coordination and anticipation, movement control and manipulative motion [Johansson et al., 2001; Pelz et al., 2001]. Van Halewyck et al. concluded that withdrawing visual feedback had a clear impact on endpoint accuracy in general. The overall percentage of target hits dropped by more than 60% and the mean aiming error increased over sevenfold (both $p < .0001$). Our study results confirm the thesis suggested by Van Halewyck's et al. that visual feedback has a clear impact on reaction time changes [Van Halewyck et al., 2014]. The study of reaction made by Kida and others shows that time of the baseball players was significantly shorter than that of the tennis players and non-athletes. For baseball players, the reaction time of higher-skilled players was significantly shorter than that of lower-skill ed players [Kida et al., 2005]. In our study, the T group training with the reaction ball also achieved better results in reaction time tests compared to the C group, which confirms Kida's thesis. In his study, Akarsu also proves that eye-hand visual reaction time was higher in non-athletes ($P < 0.001$) and visuospatial intelligence was higher in athletes ($P < 0.01$). Sex did not significantly affect these differences. Two possible explanations for the athlete's advantages in both eye-hand visual reaction time and visuospatial intelligence are that subjects with intrinsic neurological advantages such as these can readily participate in sports, and that exercise is beneficial to eye-hand reaction time and visuospatial intelligence.

Akarsu's results show that exercise is beneficial to eye-hand reaction time and visuospatial intelligence. Sport activities may be recommended for success in other lessons such as mathematics and science in primary, middle, and high school students. Moreover, it can be asserted that all sports are beneficial for the enhancement of cognitive function (14-18) because there was not any difference among different sports mentioned in this study such as soccer, basketball, volleyball, running. [Akarsu et al., 2009].

Conclusions

Exercises with a reaction ball significantly improve the level of eye-hand coordination.

Application of the proposed set of exercises with the reaction ball results in shortening the reaction time obtained in SPANT test.

The performed experiment significantly reduced the rate of mistakes made during the reaction ball test.

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A CASE STUDY TO ANALYSE SWIMMING TECHNIQUES IN FRONT CRAWL, BACKSTROKE, BREASTSTROKE AND BUTTERFLY STROKE USING A NOVICE INERTIAL MEASURING METHOD WITH ACCELEROMETERS AND GYROSCOPES

Motyčka Jaroslav[1], Bátorová Michaela[1], Šťastný Jan[1], Pašek Miloslav[1], Lepková Hana[1], Kumpán Pavel[2]

[1]Brno University of Technology, Centre of sport activities, Brno, Czech Republic

[2]Brno University of Technology, Faculty of Mechanical engineering, Institute of Solid Mechanics, Mechatronics and Biomechanics, Brno, Czech Republic

Abstract

Top level swimming has seen a significant growth in performance over the past twenty years. The cause of this rise can be found not only in the great amount and intensity of swimming training, but also in science and research investigations in this sport. The aim of this paper is to present our new measurement method for inertial sensors and synchronous video recording used for the analysis of swimming techniques.

Since 2009, we have been using two tachographs to measure swimming speed and to carry out its analysis. Results of tachograph measurements were published previously. In addition to tachographs, since the beginning of 2017, we have been using an inertial measurement unit to measure the acceleration of swimming. This unit contains sensors of inertial variables in the MicroElectroMechanical System (MEMS) technology. Specifically, it is a triaxial accelerometer and a triaxial gyroscope. Unit control and transmission of measured data are wireless via Wi-Fi interface. Motion of the swimmers being measured is graphically and numerically evaluated, along with synchronous recordings from three underwater camcorders. In the present article, we will focus only on measurements with the inertial measuring unit where we will introduce our new measuring method for the qualitative evaluation of front crawl, back stroke, breast stroke and butterfly technique of selected probands. For the measurement, probands swam their entire distance with an accelerometer mounted on a belt above their pelvic bone.

When measuring with the accelerometer unit on 8 March, 26 April, 31 May, 18 September 2017, the national team of OLYMP Sport Centre of the Ministry of the Interior was measured, of which we selected for our case study: M.J. (year 1997) - front crawl. On the 100-metre track, in the first twenty-five metres, the proband reached the swimming efficiency of 98.4% with a coefficient of variation of 0.074% and swam at a mean speed of 2.29 m.s^{-2}. The proband K.D. (1993) reached, on the 100-meter track,

in the first twenty-five metres, the swimming efficiency of 98.7%, with the coefficient of variation of 6.74% and the mean speed of 1.93 $m.s^{-2}$. The proband T. J. (1995) swam the 100-metre track of breast stroke and reached the swimming efficiency of 84% with the coefficient of variation of 25.63% and the mean swimming speed of 1.39 $m.s^{-2}$. The proband J. B. (2000) swam the 50-metre track of butterfly stroke in the first twenty-five metres with the swimming efficiency of 90.22%, the coefficient of variation 18.88% and the mean speed of 1.51 $m.s^{-2}$.

The conducted research measurements have confirmed the ability of the new inertial unit with synchronous video recording to deliver reliable results from the speed and acceleration recording; this allows us to accurately and, in greater detail, analyse the respective swimming cycles. Thanks to these results, we can advise the coaches to correct the errors in the swimming technique and thereby to improve their swimming performance.

Key words: *Swimming speed, acceleration, inertial measuring unit, accelerometer, efficiency of swimming technique.*

Introduction

An important part of the increase in sports performance is the technique of swimming style. This is related to the development of measurement methods and devices for coaches and swimmers to analyse speed and acceleration while correcting errors in swimming technique. Accelerometer measurement is now an increasingly expanding method used for the analysis of swimming and measurement of acceleration. These small systems are lightweight and by no means limit swimmers during swimming or affect the swimmer's technique.

As early as in the seventies and eighties, Professor Motyčka published in his doctoral thesis (1979) the implementation of test measurement using accelerometers in two axes. However, due to the technology capabilities of that time, it was not possible to evaluate the acceleration record and use it for coaching practice.

The use of accelerometers is constantly evolving, they are getting smaller and lighter, and their operating time increases due to lower power requirements and increased battery capacity. Dadashi et al. (2013) present measurement using one accelerometer to record swimming acceleration over the entire length of the pool. The data connection can be radio (Stamm, James, Burkett, Hagema & Theil, 2013), or the record is stored off-line and then downloaded to the PC. Scientists Puel, Seifert and Hellard (2014) developed a Ciren prototype based on a NANO MEMSense inertial measurement unit consisting of a combined triaxial accelerometer (± 5 g), a magnetometer (± 1.9 Gauss) and a gyroscope (± 600 °/s) and an integrated control unit that records data at 150 Hz.

This paper aims to introduce a new measurement method using accelerometers with gyroscopes along with synchronous video recording on the case studies of all four swimming techniques.

Methods

After eight years of swimming speed measurement by two tachographs, the Centre of Sports Activities at Brno University of Technology (CESA BUT in Brno) has expanded the measurements by measuring the acceleration of swimming by means of an inertial measurement unit. It consists of a triaxial accelerometer and a triaxial gyroscope. Transferring measured data from accelerometers to a computer is wireless. The accelerometer with a gyroscope and a battery is located in a waterproof housing. The accelerometer is mounted on a special belt with an anti-inertial release mechanism. The accelerometer belt is switched on when fixed on the measured swimmer above the pelvic bone. The measured swimmer descends to the pool water and after the starting command, he/she swims the measured race track at the highest possible speed. The movement of the swimmer being measured is synchronous with the acceleration measurement recorded by three underwater camcorders (front, rear, and movable lateral).

Special software on the computer measures the mean speed of the measured swimmer. The variation coefficient is calculated from the mean speed and the standard deviation. From the ratio of two swimming works, the efficiency of the swimming technique is calculated.

Theoretical approaches to evaluation of swimming speed measurement and instructions for measured swimmers.

Mean speed ($m \cdot s^{-1}$)

The mean speed affects all measured variables. Prior to the research, we ask the measured swimmers to ensure that their mean speed of swimming in each measurement (arms, legs, interplay) is as high as possible and exceeds their race speed.

Standard deviation ($m \cdot s^{-1}$)

The standard deviation measures the deviation from a steady swimming speed and should be as low as possible.

Variation coefficient (%)

The variation coefficient is the ratio of the mean speed and the standard deviation expressed in %. With its large span in every swimming technique and element, it is a very sensitive indicator of swimming technique. The variation coefficient should be as low as possible.

Variance ($m^2 \cdot s^{-2}$)

The variance provides information on the amount of energy required to maintain a steady speed. The greater the value of variance, the more energy the measured person has to release to maintain the mean speed. This data is particularly important for swimmers who compete on long tracks; therefore, it should be very low. (We report it in the main protocol of the measured swimmer. In the tables presented, this data is not given for the briefness of the tables).

Efficiency of swimming technique (%)

The efficiency of swimming technique is calculated from the work performed during swimming. It is the work at steady speeds broken by the real work corresponding to the actual varying swimming speeds being measured. In each measured element (legs, arms, interplay), the efficiency of the swimming technique should be as close as possible to 100 %.

Evaluation of conducted measurements

After measurements in the swimming pool, we evaluate the measured data and video recordings. Out of 25 - metre track recordings of speed and acceleration, we evaluate that part of swimming where speeds and accelerations of the swimmer have not been affected by the increased speed after push-off from the pool wall. In the software, we provide the necessary data about the swimmer to be measured and the technical data evaluated: mean speed ($m \cdot s^{-1}$), standard deviation ($m \cdot s^{-1}$), variation coefficient (%), efficiency of swimming technique (%), variance ($m^2 \cdot s^{-2}$); achieved percentage of personal maximum speeds (records) and a description of what was tested (legs, arms, interplay and length of track of 25, 50, 100, 200, 400 metres).

Results

For our contribution, we have set a hypothesis which claims that the lower the speed and acceleration variations, the more perfect the swimming technique.

The results of the conducted measurements are shown in Tables 1 to 4.

Table 1. Numerical evaluation of front crawl

Front crawl						
Proband	Sex	Year of birth	Date of measurement	Mean speed [m.s^{-1}]	Variation coefficient [%]	Efficiency [%]
M. J.	man	1997	8/ 3/ 2017	1.91	8.43	97.91
			8/ 3/ 2017	1.91	8.91	97.67
			26/ 4/ 2017	2,27	7.73	98.23
			26/ 4/ 2017	2.0	8.80	97.74
			18/ 9/ 2017	2.205	6.08	98.91

The results of front crawl sprint in the Czech Republic are very poor in terms of performance in world competitions. This low level of performance efficiency of Czech swimmers is also caused by errors in swimming technique. According to our research, the fundamental errors are as follows. Firstly, in the final phase, the stroke of arms reaches the vertical position under the body where the swimmers draw their arm to the body with the elbow and continue their strokes with ever-shortening forearms. Some swimmers complete their strokes right vertically under their body. The second error is related to the work of crawl legs. In most of our top-level swimmers, the foot in the phase of aspiration is twisted outside at a right angle from the spine. This position of the foot enlarges the position of the body at the surface, especially the head, which extends the time required for aspiration.

The abovementioned errors in swimming technique are also observed in M. J. Based on the evaluation of measurements, with synchronous video recordings, we started to eliminate these errors. Table 1 and video recordings show a gradual increase in measured values, which can be attributed to the elimination of these errors.

Table 2. Numerical evaluation of backstroke

Backstroke						
Proband	Sex	Year of birth	Date of measurement	Mean speed [m.s^{-1}]	Variation coefficient [%]	Efficiency [%]
K. D.	man	1993	8/ 3/ 2017	1.71	6.99	98.54
			26/ 4/ 2017	1.93	6.74	98.66
			31/ 5/ 2017	1.68	7.08	98.52

The proband K. D. made great efforts to achieve the first place in the Czech Republic in backstroke disciplines. He was not successful. Our measurements have shown that the error difficult to eliminate in swimming technique is related to the work of backstroke legs. Although he has been racing for more than ten years, his ankles have remained stiff and immobile. Each recorded swimming section, in which the backstroke legs worked, was characterized by a gradual decline in swimming speed. The proband has prematurely terminated his inclusion in the top-level sport centre and found a job; he trains himself once a day after work.

Table 3. Numerical evaluation of breast stroke

Breaststroke						
Proband	Sex	Year of birth	Date of measurement	Mean speed [m.s^{-1}]	Variation coefficient [%]	Efficiency [%]
T. J.	man	1995	31/ 5/ 2017	1.388	25.63	83.99
			31/ 5/ 2017	1.41	23.79	85.88
			18/ 9/ 2017	1.887	22.18	87.42
			18/ 9/ 2017	1.24	24.50	85.06
			18/ 9/ 2017	1.389	23.4	86.14

The swimmer T. J. comes from a swimming family. His parents work as coaches of swimming. Table 3 shows significant variations in all indicators. Video recordings show muscle stiffness and low mobility in the joints. Being a swimmer with an extraordinary interest in top-level swimming, we will try to eliminate the above shortcomings in cooperation with his coach.

Table 4. Numerical evaluation of butterfly stroke

Butterfly stroke						
Proband	Sex	Year of birth	Date of measurement	Mean speed [m.s^{-1}]	Variation coefficient [%]	Efficiency [%]
J. B	woman	2000	31/ 5/ 2017	1.51	18.88	90.22

The seventeen-year-old swimmer J. B., a grammar school student, showed a great talent in all four swimming techniques and very good genetic dispositions (height 182 cm, weight 69 kg) when measured. She has been training the butterfly swimming technique for only one year. This technique has extraordinary demands on the strength in the arms. The efficiency of swimming technique shows that J. B is well prepared for this discipline in terms of strength. Video recording shows that J. B. should even better master dolphin kicks with the whole body.

Discussion and Conclusion

Our new inertial measurement unit with triaxial accelerometers and triaxial gyroscopes with wireless signal transmission via Wi-fi demonstrated the full readiness to carry out the required measurements.

The tables show reliable and significant information on swimming technique of probands measured. The hypothesis chosen, in which we claim that the smaller the speed and acceleration variations, the more perfect the swimming technique, was numerically and graphically confirmed.

In further research, we assume that we will also focus on the analysis of the course of angular velocity, rotation of movement, and angular rolling of the measured person.

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Appendices

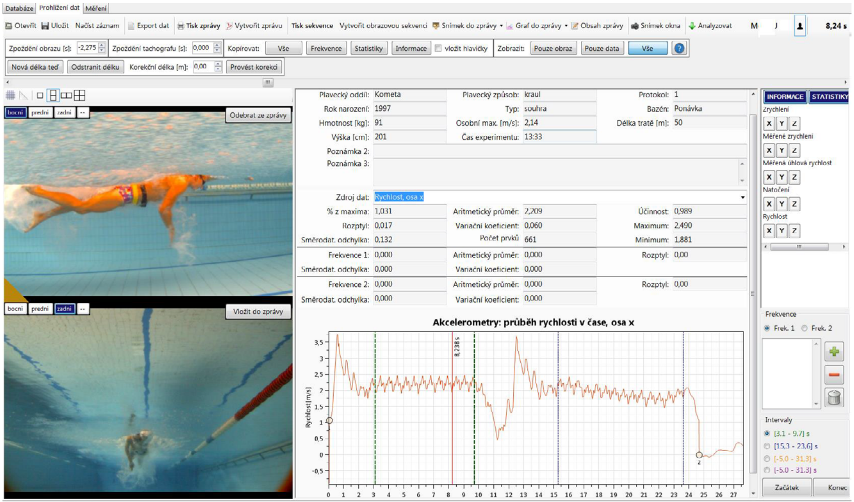

Figure 1. Graphical and numerical record of the front crawl swimming technique with video recording

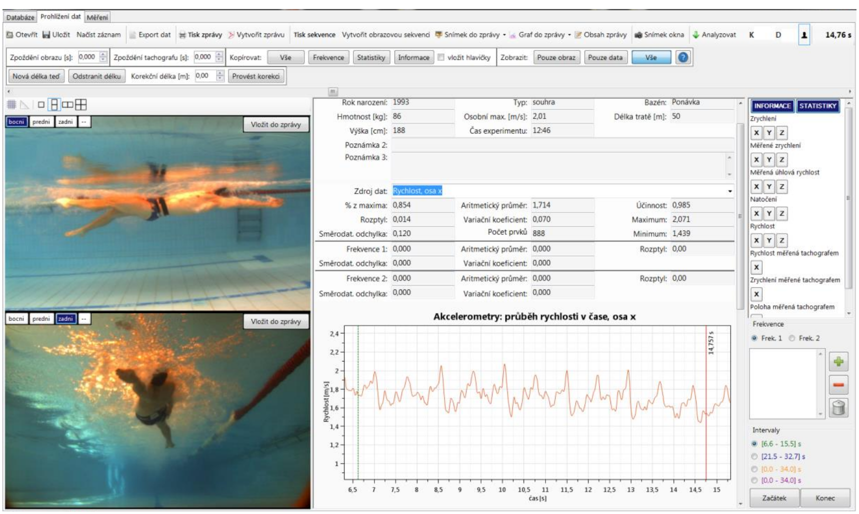

Figure 2. Graphical and numerical record of the backstroke swimming technique with video recordings at the point of the highest decrease in speed.

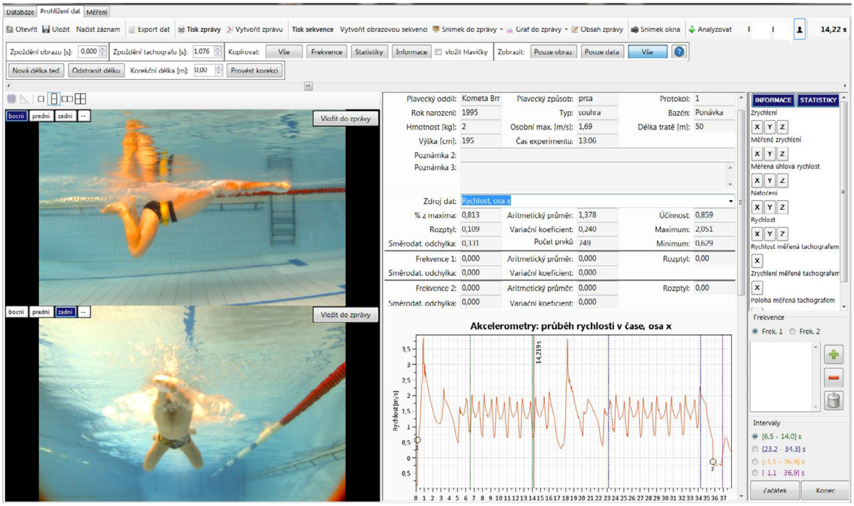

Figure 3. Graphical and numerical record of the breaststroke swimming technique with video recordings

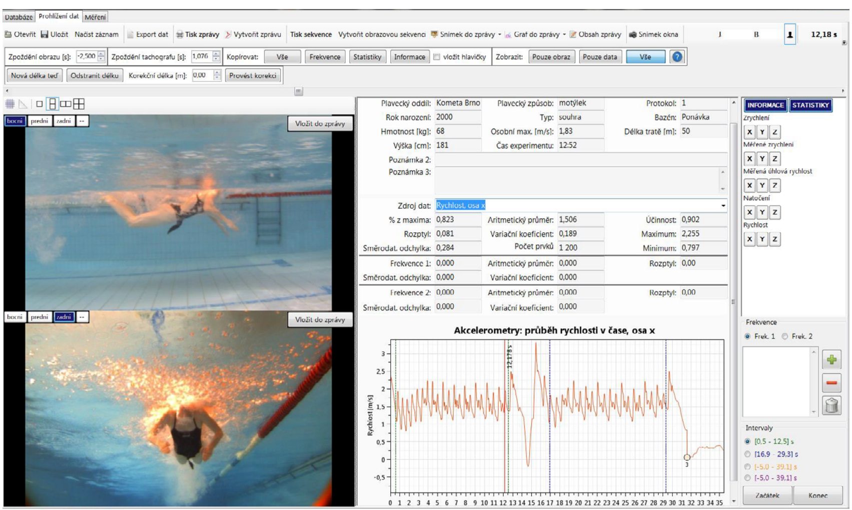

Figure 4. Graphical and numerical record of the butterfly swimming technique with video recordings

SHOULD WE OBSERVE STANDING- AND RUNNING-VERTICAL-JUMPS AS UNIQUE OR SEPARATED QUALITIES FOR HIGH LEVEL BASKETBALL PLAYERS?

Spasic Miodrag[1], Pehar Miran[2], Bjelanovic Luka[1], Uljevic Ognjen[1], Sekulic Damir[1]
[1] University of Split, Faculty of Kinesiology; Split; Croatia
[2] University of Mostar; Faculty of Natural Sciences, Mathematics and Education; Mostar, Bosnia and Herzegovina

Abstract

Purpose: Vertical jumping is important capacity in basketball, but studies mostly observed jumps performed from standing position (STAND-VJ). Meanwhile, running-vertical jumps (RUN-VJ) are rarely examined, and there is no study which systematically observed associations between STAND-VJ and RUN-VJ in basketball. The aim of this study was to evidence associations which may exist between STAND-VJ and RUN-VJ in high-level basketball players, separated for position played in game.

Methods: The sample of participants included 93 basketball players (age: 21.8±3.9 years; body mass: 89.1±11.1; body height: 194.4±8.1 cm), involved at highest national competitive levels (1st and 2nd Division). Participants were divided into three playing positions: Guards (N = 43), Forwards (N = 19), and Centers (N = 31). The variables included three STAND-VJ performances: countermovement jump (CMJ), drop-jump (DROPJ), and 6-consecutive-vertical-jumps; and four RUN-VJ performances: lay-up-shot-jumps from dominant- (LUP-D), and non-dominant leg (LUP-ND), maximal running vertical jump from dominant (MAXR-D), and non-dominant leg (MAXR-ND). The Pearson's correlation, and factor analysis with subsequent Varimax rotation were calculated to determine associations between jumping tests. Analyses were stratified by playing position.

Results: Reliability of all tests was appropriate to high, with ICC values ranging from 0.80 (for LUP-ND), up to 0.92 (for CMJ and MAXR-D). Pearson's correlation coefficients among STAND-VJ and RUN-VJ were lowest in Guards (r: 0.34-0.44), followed by Forwards (r: 0.21-0.75), and Centers (r: 0.54-0.69). Factor analysis calculated for Guards identified two independent latent dimensions of standing- and (ii) running-jump-capacity (Factor Variance: 3.47 and 1.49, respectively). For Forwards, two factors were also identified, and the first-one was correlated with CMJ, DROPJ, MAXR-D and LUP-D (Factor Variance: 3.07), and the second-one correlated to MAX-ND and LUP-ND (Factor Variance: 2.42). For Centers, one significant latent dimension was extracted, with similar correlations of all jumping tests with factor component (Factor Variance: 5.03).

Conclusion: Results indicate necessity of differential approach in conditioning of standing- and running-vertical- jumping-performances for playing positions in basketball. For Guards and Forwards separated conditioning of standing- and running-jumps is needed. Meanwhile, it seems that standing- and running-jumping-performances for Centers may be developed simultaneously.

***Key words**: testing, conditioning, jumping abilities, basketball*

Introduction

In addition to appropriate body built, technical and tactical knowledge, agility and precision, jumping ability is a crucial determinant of success in basketball (Ostojic, Mazic, & Dikic, 2006). Since game is oriented around a basket set at 3.05 m, vertical jumping abilities are particularly emphasized, and players with superior jumping ability are able to outperform their opponents in numerous situations requiring offensive and defensive responsibilities, such as blocking, jump shooting, and rebounding. As a results, professionals involved in basketball are highly interested in testing and developing vertical jumping ability of the players (Khlifa et al., 2010).

There are several different types of jumps that occur in basketball. In general, they can be divided into jumps that are performed from a standstill position (standing jumps) and jumps that are performed after running (running jumps). Specifically, in some situations, athletes perform standing jumps (e.g., rebounding by Centers, mostly when blocking an opponent's shot, performing jump shots), while in other situations, jumps are performed after running (e.g., rebounding by backcourt players, dunking, lay-ups). However, most of the basketball studies that have investigated jumping capacity have tested standing jumps (i.e., countermovement jump, squat jump) (Ben Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010; Erculj, Blas, & Bracic, 2010; Ostojic et al., 2006; Rouis et al., 2015). Meanwhile, although recognized as being an important component of the game, running jumps are rarely investigated. More specifically, apart from one recent study where authors determined high applicability of running jumps in defining differences between playing positions and playing levels, there is as evident lack of studies which examined the running vertical jumps in basketball sport (Pehar et al., 2017). Moreover, to the best of our knowledge no study systematically examined relationships between standing jumps and vertical jumps for different playing positions in basketball.

This study aimed to evaluate associations that may exist between standing- and running-vertical jumps in high-level basketball players, separated for position played in game. The advanced knowledge on a problem will allow more accurate approach in strength and conditioning in basketball sport, with regard to specifics of vertical jumping according to playing position. The leading hypothesis of the study was that associations between running- and vertical-jumps will differ across three main playing positions in basketball (i.e. Guards, Forwards, and Centers).

Methods

Subjects: In this study, we tested 93 male basketball players (age: 21.8±3.9 years; body mass: 89.1±11.1; body height: 194.4±8.1 cm). At the time of testing (competitive season 2014-2015), the athletes were involved in the highest National competitive ranks in Bosnia and Herzegovina (i.e. 1st and 2nd division). Testing was performed at the beginning of the season, and all of the subjects underwent a preseason preparation period of at least one month before the testing was performed. Only subjects who had no injuries and/or illnesses for 30 days before the experiment were included in this investigation. The players were categorized as Guards (n = 43), Forwards (n=19) and Centers (n = 31). The Ethical Board of the first author's institution provided approval of the research experiment (No: 2181-205-02-05-14-001). The average training frequency of all subjects ranged from 4 to 10 training sessions per week, depending on the competitive level.

Variables: The variables in this study included the participants' playing position, anthropometrics and seven tests of jumping capacities. The anthropometric variables (body height, reach height, and body mass) were measured with Seca stadiometers and scales (Seca, Birmingham, UK)). The jumping tests included three standing vertical-jumps: countermovement jump (CMJ), drop-jump (DROPJ), and 6-consecutive-vertical-jumps (6VJ); and four running vertical-jumps: lay-up-shot-jumps from dominant- (LUP-D), and non-dominant leg (LUP-ND), maximal running vertical jump from dominant (MAXR-D), and non-dominant leg (MAXR-ND). Standing vertical-jumps were measured by Optojump equipment (Micgrogate Bolzano, Italy), and running vertical jumps were evaluated by modified VERTEC measuring system (Vertec, Sports Imports, Hilliard, OH). The CMJ began with the athlete standing in an upright position. A fast downward movement to about a 90° knee flexion was immediately followed by a quick upward vertical movement as high as possible, all in one sequence. The test was performed without an arm swing, as the hands remained on the hips. To evaluate 6VJ, the subjects performed 6 consecutive straight-leg vertical jumps. Each jump was assessed for the height jumped and the time spent on the ground developing the force required for each jump (contact time). The ratio of each jump height to its corresponding contact time was calculated, and the average value of 6 jumps is used as final result for each trial. For the DROPJ subjects were instructed to step of the 40-cm high box and to perform maximal vertical jump as quickly as possible (i.e. to minimize the contact time). Ratio between height and contact time was calculated. The MAXR-D, and MAXR-ND were tested as the maximal vertical jump after a self-determined running approach with take-off from the left or right leg. The subjects used an individually determined running approach (max 5 m distance from start to take-off) and performed a bounce jump with an arm swing. For the LUP_D and LUP_ND, the subjects were instructed to use a two-step approach (i.e. approach similar to one when performing lay-up shoot) with a right- or left-leg take-off. This task was followed by a quick upward vertical jump, accompanied with one arm maximal reach height. Originally, the subjects were asked to use a right- or left-leg take-off for all running jumps. Later, the performances from the left and right leg were compared, and the better one was considered the jump that was performed by the dominant leg. The final achievement for running-jumps was calculated as the difference between the standing reach height and the test results as recorded on the VERTEC apparatus. All tests were done throughout three trials, and after the calculation of reliability the best achievement was used as a final result for each subject.

Statistics: The reliability of the tests was determined by Intra-Class-Coefficients (ICC). After the analysis of normality of distribution by Kolmogorov Smirnov test, the means and standard deviations were reported for all variables. To determine the relationships between vertical jumping tests, Pearson's moment correlation, and factor analysis were calculated. Factors analysis included Guttman-Kaiser criterion of extraction of significant latent dimensions, with subsequent Varimax normalized rotation of significant factor components, Analyses were stratified by playing position.

Results

Reliability of all tests was appropriate to high, with ICC ranging from 0.80 (for LUP-ND), up to 0.92 (for CMJ and MAXR-D) (Table 1). Therefore, a final result for each subject was recorded as a best achievement on three trials for each test.

Table 1. Descriptive statistics for three playing positions with overall reliability of the tests (Intra Class Coefficient – ICC)

	ICC	Guards Mean±SD	Forwards Mean±SD	Centers Mean±SD
Body height (cm)	-	188.11±5.50	197.14±5.00	202.72±5.11
Body mass (kg)	-	81.71±6.04	90.89±6.11	97.76±10.51
CMJ (cm)	0.92	46.13±6.04	45.41±5.14	43.21±5.36
DROPJ (index)	0.81	1.73±0.22	1.60±0.42	1.42±0.12
6VJ (index)	0.82	1.49±0.33	1.79±0.32	1.44±0.41
LUP_D (cm)	0.88	73.21±7.76	72.11±6.00	69.11±6.98
LUP_ND (cm)	0.80	69.00±7.11	67.11±7.01	62.81±6.44
MAXR_D (cm)	0.92	77.71±10.01	74.32±5.91	71.99±8.91
MAXR_ND (cm)	0.87	70.02±8.99	70.58±7.68	65.03±7.23

Legend: CMJ - countermovement jump, DROPJ - drop-jump, 6VJ - 6-consecutive-vertical-jumps, LUP-D - lay-up-shot-jump from dominant leg, LUP-ND – lay-up-jump-shot from non-dominant leg, MAXR-D - maximal running vertical jump from dominant leg, MAXR-ND – maximal running vertical jump from non-dominant leg

Table 2 presents correlation coefficients between jumping tests, calculated separately for Guards, Forwards, and Centers. Pearson's correlation coefficients among standing vertical jumps and running vertical jumps were lowest in Guards (r: 0.15-0.44), followed by Forwards (r: 0.21-0.75), and Centers (r: 0.54-0.69).

Table 2. Pearson's correlation coefficients for jumping tests calculated separately for three playing positions

	Position	CMJ	DROPJ	6VJ	LUP-D	LUP-ND	MAXR-D
DROPJ	Guards	0.45*					
	Forwards	0.38					
	Centers	0.61*					
6VJ	Guards	0.45*	0.64*				
	Forwards	0.43	0.41				
	Centers	0.56*	0.56*				
LUP-D	Guards	0.43*	0.34*	0.15			
	Forwards	0.75*	0.64*	0.56*			
	Centers	0.57*	0.55*	0.69*			
LUP-ND	Guards	0.41*	0.43*	0.34	0.70*		
	Forwards	0.45	0.21	0.45	0.63*		
	Centers	0.66*	0.57*	0.68*	0.84*		
MAXR-D	Guards	0.43*	0.38*	0.35	0.73*	0.83*	
	Forwards	0.66*	0.68*	0.51*	0.49*	0.94*	
	Centers	0.67*	0.57*	0.62*	0.78*	0.89*	
MAXR-ND	Guards	0.44*	0.38*	0.35	0.89*	0.78*	0.81*
	Forwards	0.51*	0.25	0.56*	0.82*	0.51*	0.35
	Centers	0.59*	0.54*	0.62*	0.91*	0.75*	0.78*

*Legend: CMJ - countermovement jump, DROPJ - drop-jump, 6VJ - 6-consecutive-vertical-jumps, LUP-D - lay-up-shot-jump from dominant leg, LUP-ND – lay-up-jump-shot from non-dominant leg, MAXR-D - maximal running vertical jump from dominant leg, MAXR-ND – maximal running vertical jump from non-dominant leg, * denotes statistical significance of p < 0.05*

Table 3. Factors analysis results for three playing positions

	Guards		Forwards		Centers
	F1	F2	F1	F2	F1
CMJ	0.38	0.69	0.69	0.47	-0.78
DROPJ	0.24	0.75	0.79	0.01	-0.73
6VJ	0.03	0.90	0.45	0.57	-0.79
LUP-D	0.87	0.23	0.85	0.46	-0.92
LUP-ND	0.90	0.13	0.20	0.90	-0.91
MAXR-D	0.92	0.22	0.90	0.28	-0.89
MAXR-ND	0.89	0.23	0.14	0.94	-0.90
Expl.Var	3.40	2.07	2.91	2.52	5.03
Prp.Totl	0.49	0.30	0.42	0.36	0.72

Legend: CMJ – countermovement jump, DROPJ – drop-jump, 6VJ – 6-consecutive-vertical-jumps, LUP-D – lay-up-shot-jump from dominant leg, LUP-ND – lay-up-jump-shot from non-dominant leg, MAXR-D – maximal running vertical jump from dominant leg, MAXR-ND – maximal running vertical jump from non-dominant leg, F – structure of significant latent dimensions/factors, Expl.Var – factor's variance, Prp.Totl – total proportion of the explained variance

Factor analysis calculated for Guards identified two independent latent dimensions - factors of (F1) running- and (F2) standing-jumping-capacity (Factor Variance: 3.4 and 2.1, respectively). For Forwards, two significant factors were also identified, and the first-one (F1) was correlated with CMJ, DROPJ, MAXR-D and LUP-D (Factor Variance: 2.9), and the second-one (F2) was correlated to MAX-ND and LUP-ND (Factor Variance: 2.5). For Centers, one significant latent dimension was extracted (F1), with similar correlations of all jumping tests with factor component (Factor Variance: 5.0).

Discussion

Our results showed that running- and standing-vertical jumps held weaker correlations for Guards than for other two playing positions (i.e. Forwards and Centers). Also, factor analysis revealed differential jumping-latent dimensions for three studied playing positions. Therefore, the leading hypothesis of this study was confirmed. The possible explanations together with implications of such findings is discussed in the following text.

As stated in the introduction, there is an evident lack of studies which examined the associations between running- and standing-jumps. In one the few, Sattler et al. investigated associations between spike-jump (volleyball specific running-jump), and CMJ, squat-jump and block-jump (all standing-jumps) in advanced level male volleyball players, and reported that spike-jump and standing-jumps share more than 50% of common variance (Sattler, Sekulic, Hadzic, Uljevic, & Dervisevic, 2012). Similarly Pehar et. al. recently reported relatively consistent single-factor structure when they correlated running- and standing-vertical jumps in basketball players (Pehar et al., 2017). However, both of these studies observed total-samples of players, while not dividing them according to playing position (Pehar et al., 2017; Sattler et al., 2012).

To the best of our knowledge this is the first study which systematically examined the relationships between different types of standing-jumps and several running-jumps in basketball according to playing position. In this investigation we have intentionally included jumping tests which occur in real-game basketball situations. There is no doubt that some of the observed jumps are more common for specific playing position (i.e. Guards perform running-jumps more often than other two playing positions) (Gomez, Lorenzo, Barakat, Ortega, & Palao, 2008; Wissel, 2011). However, another explanation deserves attention. In short, there is a certain possibility that those players with better jumping capacities (i.e. Guards) were genetically more explosive (e.g. simply because of their inherited physiological capacities, ratio between fast- and slow-twitch fibers etc.), and consequently responded better to the training throughout their sport career. This could logically influence here obtained differences among positions in jumping performances. However, regardless of the background (i.e. position-specific-, or physiologically-based), superior running-jumping capacity in Guards we have evidenced herein is in agreement with recent study where authors investigated position specific jumping capacities and identified Guards as being superior then Forwards and Centers in running-jumps, while no significant differences among three playing positions were found for standing-jumps (Pehar et al., 2017).

The relative independence of standing- and running-jumps in Guards actually points to the fact that some of these players are able to perform excellent standing-jumps while not being able to achieve superior results in running-jumps. Probable explanations of such phenomenon are very diverse. First, it is well known that standing vertical jumps, such as those studied herein, are correlated to sprinting performance (Hebert-Losier, Jensen, & Holmberg, 2014). Therefore, it is possible that Guards with superior standing vertical jumping performances lack control throughout running when they perform running vertical jumps. Specifically, it is possible that advanced running speed does not allow them to translate horizontal- into vertical

-velocity, and consequently alter their (running-) vertical jumping performance. It is also possible that anthropometric properties differentially influence running- and standing-vertical jumping in Guards (i.e. anthropometric differences between Point Guards and Shooting Guards are well documented) (Jelicic, Sekulic, & Marinovic, 2002; Ostojic et al., 2006). Additionally, the specific influence of jumping technique is also possible. However, for a more profound analysis of this problem, the evaluation of anthropometric, biomechanical and neuromuscular properties of the muscles is needed. Although such analyses will be undoubtedly important, for the purpose of this study the real physiological background of these findings is not crucial. Namely, it is clear that standing- and running-jumps are independent qualities in Guards, which has direct implications on strength training and conditioning of jumping capacities for players involved at that position during basketball game. In short, standing- and running-vertical-jumping performances in Guards should be conditioned specifically and independently.

While standing- and running-jumps are independent qualities in Guards, in Centers these two types of jumps should be observed as unique capacity. Evidently, those Centers who perform excellent jumps from standing position are able to translate such performance in running jumps also (and vice-versa). Because of the well-defined playing duties, and position during basketball game, Centers are not frequently in situation to perform running-jumps (Wissel, 2011). Also, there is no doubt that their real-game performance is more dependent on their standing-jumping qualities (Sampaio, Godoy, & Feu, 2004). Therefore, it is questionable is it necessary to develop their running-jump capacities? Our results on strong correlation between standing- and running-jumps for these players additionally support such observation. Namely, it is very probable that development of one of these capacities will positively influence the other one also. Therefore, we may suggest that conditioning programs aimed at development of jumping performance in Centers should be oriented toward standing-jump performance.

For Forward players, specific jumping performance of the dominant-leg seems to be crucial factor of their overall jumping performance. Although this study included relatively small number of players involved at this playing position, results of the correlation- and factor-analyses point to such conclusion. It is probable that the specific body built (i.e. Forwards are relatively tall, but mostly ectomorph) (Jelicic et al., 2002), together with specific game duties (small forwards are regularly observed as most versatile of all basketball players and therefore close to Guards, while Power forwards share playing duties with Centers) (Wissel, 2011), resulted in such specific correlations among observed jumping capacities. Whatever the reason may be, development of muscular properties of dominant leg could be suggested as an appropriate training approach in development of jumping capacities of basketball Forwards.

Conclusion

This study was designed in order to define associations between vertical running-jumps and vertical standing-jumps in basketball. Results showed differential associations between these two groups of jumping performances for three playing positions. Therefore, our results have specific applicability in conditioning of jumping performances in basketball. Namely, running- and vertical-jumping performance should be separately conditioned among Guards. For that purpose, influence of specific running technique, transfer from the horizontal-to-vertical displacement and other biomechanical factors should be taken into account. Among forwards, standing vertical jumps are clearly connected with running-jump performances executed from dominant leg. As a result, development of mechanical (jumping) properties of dominant leg will probably result in improvement of these capacities among Forward players. Meanwhile, strong associations between all applied jumps indicate that both standing- and running-vertical jumps could be developed simultaneously in Centers. In doing so, standing vertical jumping exercises are suggested.

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A TOTAL SAMPLE VS. PLAYING-POSITION APPROACH TO IDENTIFYING RELATIONSHIPS BETWEEN DIFFERENT AGILITY COMPONENTS IN BASKETBALL

Uljevic Ognjen[1], Pehar Miran[2], Pojskic Haris[3,4], Spasic Miodrag[1], Sekulic Damir[1]
[1] University of Split; Faculty of Kinesiology; Split; Croatia
[2]University of Mostar; Faculty of Natural Sciences Mathematics and Education; Mostar; Bosnia and Herzegovina
[3] Mid Sweden University; Swedish Winter Sports Research Centre; Östersund; Sweden
[4] Mid Sweden University; Faculty of Human Sciences, Department for Health Sciences; Östersund; Sweden

Abstract

Purpose: Non-planned agility (reactive agility – RAG), and pre-planned agility (change of direction speed – CODS) are important determinants of success in basketball. However, the association between these two conditioning capacities in high-level basketball players is rarely evidenced. The aim of this investigation was to evaluate the relationship between basketball-specific CODS and RAG in the total sample, and separately for three main playing positions in the game of basketball (i.e. guards, forwards and centers).

Methods: The sample comprised 106 national/international-level male basketball players (age: 21.9±3.5 years; body height: 195.1±7.9 cm; body mass: 90.1±10.0 kg), divided according to their playing positions in game (guards, N = 49; forwards, N = 22; centers, N = 35). The variables included body mass, body height, and body fat percentage; as well as basketball-specific CODS and -RAG. The reliability of CODS and RAG was evidenced by intra-class-coefficients (ICC). Differences among positions were established by one-way analysis of variance, consecutive post-hoc analyses, and effect size differences (η^2). Finally, the relationship between variables was established by means of Pearson's moment correlation coefficient (r), which was calculated for the total sample, and then separately for each playing position.

Results: The intra-session reliability was somewhat higher for CODS, than for RAG (ICC: 0.81 and 0.76, respectively). The centers were tallest (F: 67.75, $p < 0.01$; η^2: 0. 57), and heaviest (F: 39.01, $p < 0.01$, η^2: 0.44), followed by forwards. The guards and forwards achieved better results than centers in CODS (F: 5.19, $p < 0.01$; η^2: 0.09), and RAG (F: 3.85, $p < 0.05$; E η^2: 0.07). When observed for the total sample, the CODS and RAG shared 49% of common variance (r: 0.70). When calculated for playing positions, the highest correlation between CODS and RAG was evidenced for centers (r: 0.81), then for forwards (r: 0.71), and guards (r: 0.51).

Conclusion: Relatively strong correlations between CODS and RAG among forwards and centers implies the possibility of simultaneous strength and conditioning of these capacities for these two playing positions. Meanwhile, because of the small common variance, separate training for RAG and CODS is warranted for guards. The study highlights the necessity of a position-specific approach to evidencing determinants of sport-specific conditioning qualities for high-level players.

Key words: *pre-planned agility, non-planned agility, team sports, sport-specific test*

Introduction

Agility is a performance which directly contributes to success in sports where there is a clear need to rapidly change direction, such as basketball, soccer, handball, etc. (Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013; Sisic, Jelicic, Pehar, Spasic, & Sekulic, 2016; Spasic, Krolo, Zenic, Delextrat, & Sekulic, 2015). Basketball athletes with superior agility are able to outperform their opponents in numerous situations and duels, such as positioning during offence of defense, blocking, counterattacking etc. For example, during defensive duties, better agility allows a defender to 'lock down' a player with the ball and keep him away from the basket and possibly cause a turnover. During offence, advanced agility allows a player to beat the opponent to the basket and have an easier time scoring (Delextrat, Grosgeorge, & Bieuzen, 2014). It is therefore not surprising that agility is emphasized as one of the most important capacities in basketball (Pehar et al., 2017).

Today, it is generally accepted that a clear distinction between two types of agility should be made: pre-planned agility (e.g. closed skill agility, change of direction speed [CODS]), and non-planned agility (e.g. open skill agility, reactive agility). In general, CODS is accentuated in all situations when an athlete has an advanced knowledge of the directional change, while reactive agility is accentuated in situations when an athlete changes a direction while responding to an unpredictable stimulus (i.e. trajectory of the ball, opponent, team-mate) (Sekulic, Krolo, Spasic, Uljevic, & Peric, 2014; Sisic et al., 2016). In real-sport situations in basketball, CODS allows an athlete to outperform his/her opponent when he/she is in a position to define the movement pattern (i.e. mostly in offensive duties), and reactive agility is mostly accentuated in defensive duties (Sekulic, Pehar, Krolo, Spasic, Uljevic, Calleja-Gonzalez, & Sattler, 2017). However, regardless of the relatively known and accepted fact that reactive agility and CODS should be observed as two separate qualities, one specific problem emerges. The issue is that all studies which have examined the possible association between reactive agility and CODS in team sports have observed all players as a unique sample (Sekulic et al., 2017; Spasic et al., 2015).

Playing positions in basketball are highly diverse in terms of numerous fitness parameters (Boone & Bourgois, 2013; Pojskic, Separovic, Uzicanin, Muratovic, & Mackovic, 2015; Ponce-Gonzalez, Olmedillas, Calleja-Gonzalez, Guerra, & Sanchis-Moysi, 2015). Therefore, it is reasonable to suppose that when observing associations between reactive agility and CODS in the total sample of basketball players, a strong confounding effect of playing position occurs. On the other hand, in real-game situations basketball players are mostly opposed within playing positions. In other words, when associations between performance variables are established in a total sample of players, we do not learn much about the association for each of the playing positions. Such information would be highly important for developing targeted conditioning programs for each playing position.

The aim of this investigation was to evaluate the relationship between basketball-specific CODS and reactive agility in the total sample, and separately for three main playing positions in the game of basketball (i.e. guards, forwards and centers). Knowledge of these associations will allow a more accurate conditioning of these important capacities in basketball players. The leading hypothesis of this study was that correlations between reactive agility and CODS will differ across the three main playing positions in basketball.

Methods

Subjects: The sample comprised 106 professional-level male basketball players (age: 21.9±3.5 years; body height: 195.1±7.9 cm; body mass: 90.1±10.0 kg). All players were members of teams competing at two highest national levels (i.e. first and second division) in Bosnia and Herzegovina in the 2014/15 season. For the purpose of this investigation, players were divided according to their playing positions in the game, and were classified as guards (N = 49), forwards (N = 22), and centers (N = 35). Testing was performed at the beginning of the season, and all the subjects underwent a preseason preparation period of at least one month before the testing was performed. Only subjects who had no injuries and/or illnesses for 30 days before the experiment (based on a health history questionnaire completed prior to testing) were included. The Ethics Board of the corresponding author's institution provided approval of the research experiment (No: 2181-205-02-05-14-001). All the players were informed of the purpose, benefits and risks of the investigation. All the subjects were older than 18 years and provided their own written informed consent for participation in the study.

Variables: The variables included the participants' playing position, anthropometrics (body height and mass) which were measured with Seca stadiometers and scales (Seca, Birmingham, UK). Tests for assessing agility performance, CODS – basketball-specific test of change of direction speed and RAG - the basketball-specific test of reactive agility, were adopted from previous study where authors confirmed appropriate validity of the tests in discriminating playing positions and different competitive levels (Sekulic et al., 2017). Both tests were performed in the testing area shown in Figure 1. For the RAG, the participants commenced from the start line so that timing began when they crossed the infrared IR signal. At that moment, a hardware module (microcontroller – MC) lit one of the two LEDs placed inside 30-cm high cones (labelled A and B). The participant had to assess which cone was lit, shuffle run to that particular cone, rebound the ball placed on top of the cone, and return to the start line as quickly as possible. When a participant crossed the IR signal on his way back, the timing stopped. To mimic real-game performance in basketball, the participants faced forward throughout the test. A single-test trial for each test consisted of five attempts, and the participants had no advance knowledge of the testing scenario. Three trials were performed. The rest period between attempts lasted 10-15 seconds. The CODS testing was similar to the RAG testing, but the participant had advance knowledge of which cone would light up. The participants performed five trials for each test in a random order; approximately 50% of the participants performed the CODS followed by the RAG, while the others performed the RAG followed by the CODS. The rest time between trials was approximately 1 minute; the rest time between tests was 4-5 minutes. For both tests, the best time out of five trials was retained as the final result.

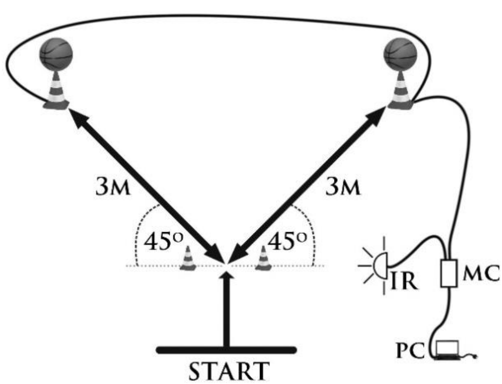

Figure 1. Testing of the reactive-agility and CODS (MC – microcontroller; IR – infrared signal; PC – personal computer)

Statistics: After assessing the normality (by Kolmogorov Smirnov's test), the means and standard deviations were reported for all variables. The reliability of CODS and RAG was evidenced by intra-class-coefficients (ICC). Differences among positions were established by one-way analysis of variance, consecutive post-hoc analyses, and effect size differences (η^2). Effect size differences were assessed using the following criteria: (small ES: >.02; medium ES: >.13; large ES: >.26) (Cohen, 1988; Ferguson, 2009).

Finally, the relationship between variables was established by means of Pearson's moment correlation coefficient (r), which was calculated for the total sample, and then separately for each playing position. The statistical significance of the differences between pairs of correlation coefficients was established using the Fisher r-to-z transformation.

Results

The intra-session reliability was somewhat higher for CODS than for RAG (ICC: 0.81 and 0.76, respectively). Differences between playing positions in the studied variables are presented in Table 1. The centers were tallest (F: 67.75, $p < 0.01$; η^2: 0. 57), and heaviest (F: 39.01, $p < 0.01$, η^2: 0.44), followed by forwards. The guards and forwards achieved better results than centers in CODS (F: 5.19, $p < 0.01$; η^2: 0.09), and RAG (F: 3.85, $p < 0.05$; η^2: 0.07).

Table 1. Descriptive statistics (mean ± standard deviation) and differences among playing positions in observed variables (ANOVA – analysis of variance; η^2 – effect size of differences) with Scheffe post-hoc analysis

	Total sample	Guards	Forwards	Centers	ANOVA (F test)	η^2
Body height (cm)	194.82±8.1	188.23±5.52 ^{F,C}	197.1±5.09	201.72±5.26	67.75**	0.57
Body mass (kg)	89.33±10.91	81.69±6.33 ^{F,C}	90.81±6.1	97.78±10.94	39.01**	0.44
CODS (s)	1.75±0.15	1.71±0.11 ^{C}	1.74±0.14	1.82±0.19	5.19*	0.09
RAG (s)	2.04±0.15	2.01±0.13 ^{C}	2.03±0.14	2.10±0.17	3.85*	0.07

*Legend: CODS – change of direction speed, RAG – reactive agility, ** denotes statistical significance of $p < 0.01$, * denotes statistical significance of $p < 0.05$; ^{F} denotes significant (at $p < 0.05$) differences between observed group and Forwards; ^{c} denotes significant (at $p < 0.05$) differences between observed group and Centers*

Pearson's product moment correlation coefficients between RAG and CODS for the total sample, and separately for guards, forwards, and centers, are presented in Figure 2. When observed for the total sample, CODS and RAG shared 49% of common variance (r: 0.70). When calculated for playing positions, the highest correlation between CODS and RAG was evidenced for centers (r: 0.81; 65% of common variance), then for forwards (r: 0.71; 50% of common variance), and guards (r: 0.51; 26% of common variance). Fisher r-to-z transformations found significant difference between correlation coefficients established for centers and guards ($z = 2.45$, $p < 0.01$), with no significant differences between other pairs of correlation coefficients ($z = 0.83$ and 1.19, both $p > 0.05$; for comparison between centers and forwards, and forwards and guards, respectively).

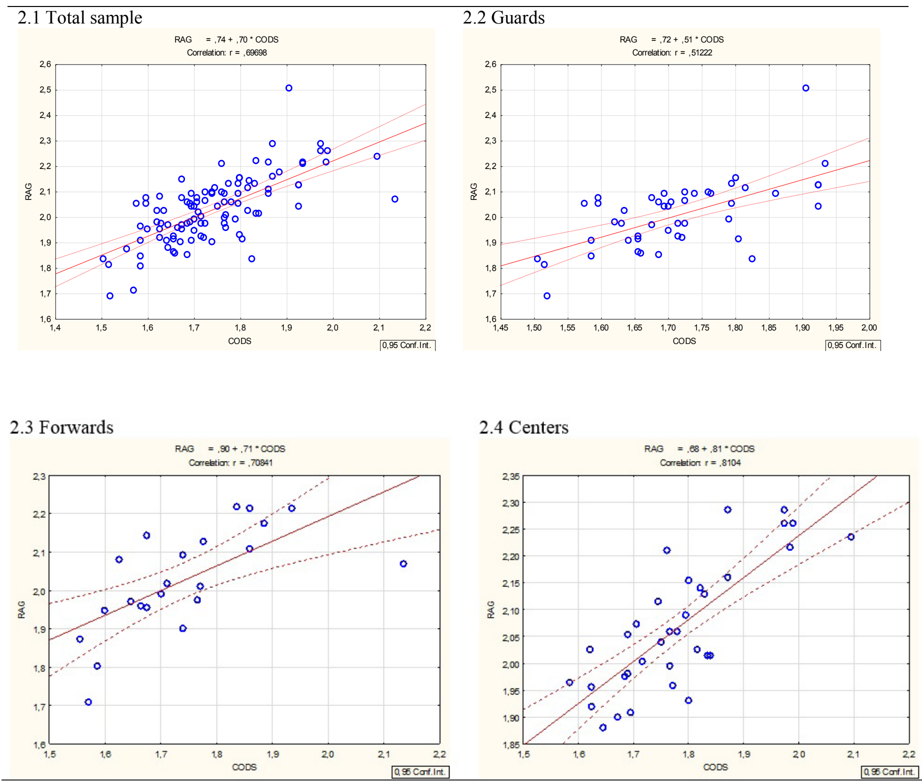

Figure 2. Pearson's moment correlation scatterplots for total sample, and separately for three positions in basketball game (Guards, Forwards, and Centers)

Discussion

The leading hypothesis of this study is confirmed, since correlations between CODS and RAG differ between playing positions. Possible explanations of such findings are discussed below.

With the increased interest in reactive agility as an important conditioning quality, there is an evident increase of studies which have directly or indirectly investigated associations which may exist between CODS and reactive agility (Sattler et al., 2015). The background idea of these studies was to evaluate the percentage of common variance between these two capacities, which would allow more accurate and meaningful development of these conditioning qualities. Specifically, if CODS and the corresponding reactive agility shared a high percentage of common variance, it would be logical to expect that these two qualities may be developed simultaneously (Sattler et al., 2015). However practically all studies which have investigated this problem have reported relatively low correlations between CODS and reactive agility, ranging from less than 2% up to 45% of common variance, and these differences have depended on the sample of subjects (i.e. lower correlations were evidenced for high level athletes in comparison to correlations found for recreational- and/or athletes of lower competitive level), and duration of tests (i.e. lower correlations were evidenced for tests of shorter duration) (Sattler et al., 2015; Sekulic et al., 2014; Spasic et al., 2015). Although discussions offered in order to explain such relative independence of CODS and reactive agility seem sound (i.e. reactive agility partially depends on cognitive and perceptual capacities, while CODS is more influenced by speed, explosive strength and/or balance), to the best of our knowledge no study has applied a position-specific approach after having evaluated associations which may exist between CODS and reactive agility in sport. Therefore, our results on differential associations between these two capacities in basketball players in different playing positions are novel.

In short, while CODS and RAG should be observed as unique conditioning capacities in forwards and centers (i.e. frontcourt players), these two qualities should be clearly differentiated in guards (i.e. backcourt basketball players). Differences in playing duties, together with differences in fitness capacities among the three studied playing positions, almost certainly explain even the established differences between correlations of RAG and CODS for backcourt and frontcourt players. It is known that during a basketball game backcourt players (i.e. guards) are frequently in situations where they have to evidence their CODS capacities. These are mainly related to their duties in offense, when they must quickly transfer the ball from defense to offense, and when they perform the (pre-planned) movement templates as a part of tactical duties in offense (Strumbelj et al., 2015). Meanwhile, the guards' reactive agility is accentuated in situations when they have to react to opponents' tactics, respond to opponents' offensive movement templates, and/or when they have to quickly react and perform the turnover. The importance of both capacities (i.e. RAG and CODS) in guards is directly supported in a recent study where Sekulic et al. reported significant differences in both of these qualities between guards involved in different qualitative playing levels (Sekulic et al., 2017). Our results clearly indicate that reactive agility (accentuated mainly during defense), and CODS (challenged mainly during offense) are independent capacities in guards. Evidently, guards with specific qualities (i.e. high levels of cognitive and perceptual qualities) are able to perform well in RAG, irrespective of their result in CODS. However, it is also evident that some guards who performed well in CODS were not able to utilize their excellent CODS, and to shift it toward superior RAG performance. It altogether points to the necessity of specific conditioning aimed at the development of CODS and reactive agility in guards.

The correlations between CODS and RAG in forwards (50% of common variance), and especially in centers (65% of common variance) point to the independence of these two capacities for frontcourt players. Most probably, this can be explained knowing the specifics of fitness status, but also the playing duties for these positions in basketball. In short, the well-defined position duties in basketball naturally result in the typical body build of players (e.g. centers are the tallest and heaviest, guards are the shortest but most mesomorph), and in their specific fitness status (Alejandro, Santiago, Gerardo, Carlos, & Vicente, 2015; Ben Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010; Koklu, Alemdaroglu, Kocak, Erol, & Findikoglu, 2011; Sindik & Jukic, 2011).With regard to playing duties, the centers are very rarely (if ever) in situations to present their CODS capacity. Therefore, it is not surprising that studies which have investigated differences between qualitative levels of centers have found similar levels of CODS for Centre-playing members of first-division teams, and those who were members of second-division teams (Sekulic et al., 2017). Meanwhile, significant differences in the reactive agility of centers according to their playing level, with superior performance in those involved in more advanced level play, is also reported (Sekulic et al., 2017). Specifically, centers are frequently responsible for defensive duties where they have to accurately and appropriately respond to an opponent's change of direction, prevent their penetration and consequent scoring. Therefore, it is not surprising that our results have evidenced the independence of CODS and RAG in centers.

The nature of correlation between RAG and CODS for forwards should be discussed knowing the specifics of two types of forward players – small forwards (SF) and power forwards (PF). That is to say that playing duties, body build and conditioning capacities of PF are similar to those of centers, while the SF are more similar to guards (Wissel, 2011). As a result, the relation between CODS and reactive agility for SF is expected to be similar to the relationship established for guards (i.e. these two qualities are independent). Meanwhile for PF, the CODS and RAG are probably more dependent (i.e. share a larger proportion of common variance), as it is established for centers. As a result, the correlation of RAG and CODS for the total sample of forwards (r: 0.70) is somewhere in between the correlation established for guards (r: 0.50) and the one established for centers (r: 0.81). We are aware that previous explanations of differential correlations between CODS and RAG in two groups of forward players are theoretical to some extent: as a consequence of the number of players in basketball teams, our study has involved a relatively small number of forwards, and consequently we haven't been able to divide them into PF and SF. Therefore, future studies with larger samples are warranted.

Conclusion

This study clearly highlights the necessity of a position-specific approach to evidencing determinants of sport-specific conditioning qualities for high-level basketball. The differences in correlations between pre-planned-agility (change-of-direction speed) and non-planned agility (reactive agility) for players involved in three main positions in the game of basketball, allow us to highlight a specific approach to the conditioning of agility performances in this sport. Specifically, a relatively high percentage of common variance between CODS and RAG among forwards and centers points to the possibility of simultaneous strength and conditioning of different facets of agility for these two playing positions. Meanwhile, because of the small common variance, separate training for RAG and CODS is warranted for guards.

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FACTORS INFLUENCING PASSING SKILLS DURING COMPETITIVE BASKETBALL GAMES

Vencúrik Tomáš, Nykodým Jiří, Bokůvka Dominik, Vacenovský Pavel
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Basketball is a team sport and thus passing in basketball is a very important offensive skill – it can lead, simply put, to assist or to turnover. The precise pass can create an advantage for the offensive team; for example, it can lead to an open shooting position. On the other hand, the inaccurate pass may create a disadvantage for the offensive team and can help the defending team. The aim of this study was to identify factors which may affect the passing skills in competitive games of women's basketball. 10 female semi-professional basketball players of the 2^{nd} division senior team participated in this study. They were, in average, 20.4±2.8 years old, with a body height of 178.5±5.2, and body weight of 65.4±5.7. Passing skills were assessed during 5 competitive games. During all games, the heart rate and its development were monitored by the telemetric device. 451 overall passes were evaluated in detail and they were categorized as accurate and inaccurate. Based on the previous research the four factors, which could be the main influence on the effectiveness (intensity of load, defensive pressure, ball possession duration, and game periods), were set as independent variables. Passing effectiveness was set as a dependent variable. Each of four factors was categorized (independent variables). Intensity of load was divided into 3 categories (<85%, 85-95%, and >95% of HR_{max}); defensive pressure had 3 categories (low, medium, and high); ball possession duration was divided also into 3 categories (0-8 s, 9-16 s, and 17-24 s); and game periods had 4 categories (1^{st}, 2^{nd}, 3^{rd}, and 4^{th}). The influence of independent variables on dependent variable was expressed by binary logistic regression. Method of backward stepwise selection was used to find the best model. Only one regression coefficient included in the final model was statistically significant – the defensive pressure of the opponent. In conclusion, the chances for the bad pass are higher when the level of defensive pressure increased. Coaches should include these findings into team practices.

Key words: *heart rate, defensive pressure, logistic regression*

Introduction

Basketball is a very dynamic sport because the complexity of movement structure (Ben Abdelkrim, El Fazaa, El Ati, & Tabka, 2007; Matthew & Delextrat, 2009; Scanlan, Dascombe, Reaburn, & Dalbo, 2012) and is characterized by variability of individual offensive skills. Basketball is a team sport and this is the reason why is passing in basketball very important offensive skill. The precise pass can create an advantage for the offensive team; for example, it can lead to an open shooting position. On the other hand, the inaccurate pass may create a disadvantage for offensive team and can help the defending team. Simply put, the pass can lead to assist or to turnover.

Motor movement of passing is very important and can be monitored externally; it represents the technique of passing. According to Palao & Morante (2013), the technical aspect of performing the offensive skills is thought to be an effective way to solve a movement task in accordance with basketball rules, biomechanical rules, and the player's mobility choices.

Ability to directly measure an offensive skill is very difficult; however, it is necessary for the future progress of the player. The performance analyses help to understand the passing performance better (O'Donoghue, 2010). There are some possibilities how to measure the effectiveness of passing and one of them is expertise observation based on the notational analysis (Chen, Hendricks, & Zhu, 2013).

The aim of this study was to identify factors which may affect the passing performance in competitive games of women's basketball.

Methods

Participants

10 female basketball players in the 2nd division of senior category, participated in this research. The average age of these players was 20.4 ± 2.8 years, the average body height 178.5 ± 5.2 cm, and the average body weight 65.4 ± 5.7 kg. The research was in accordance with the Declaration of Helsinki and all participants (or their legal representatives) signed the informed consent.

Procedure

Maximal heart rate (HR_{max}) was set by beep test. Passing skills were assessed during 5 competitive games. Two of these games were part of regular season and three games were part of playoffs. The observed team won four out of five games with difference in score from +2 points to +31 points. One game was lost by 29 points. In that season the observed team won the 2nd division and moved up to 1st division. During all games, the heart rate was monitored. 451 overall passes were evaluated in detail and they were categorized as accurate and inaccurate. The accurate pass is meant to be a pass to a teammate, to the trunk of her body and the receiver of the pass does not have a problem with catching the ball. The inaccurate pass is meant to be a pass to a teammate which is away from the trunk of her body, and receiver of the pass has a problem with catching the ball, or the passer makes a turnover (Chen et al., 2013). Based on the previous research (Álvarez, Ortega Toro, Salado, & Gómez, 2009; Vaquera, Cubillo, García-Tormo, & Morante, 2013) the four factors, which could be the main influence on the effectiveness (intensity of load, defensive pressure, ball possession duration, and game periods), were set as independent variables. Passing effectiveness was set as a dependent variable. Each of four factors was categorized (independent variables). Intensity of load was divided into 3 categories (<85%, 85-95%, and >95% of HR_{max}); defensive pressure had 3 categories (low, medium, and high); ball possession duration was divided also into 3 categories (0-8 s, 9-16 s, and 17-24 s); and game periods had 4 categories (1^{st}, 2^{nd}, 3^{rd}, and 4^{th}).

Because of the intermittent nature of basketball game, each pass was assigned the mean value of HR (from -5 to +10 seconds since the release of the ball). Heart rate and its development were monitored by commercially available telemetric device Suunto Team (Suunto Oy, Vantaa, Finland). All games were recorded on digital camera HG10 (Canon Inc., Tokyo, Japan). For the notational analysis, the software Dartfish TeamPro 6.0 (Dartfish, Fribourg, Switzerland) was used. To evaluate the passing performance, the players had to be active for at least 10 minutes of the live time and in both game halves.

Statistical analysis

The influence of independent variables on the dependent variable (only two options—accurate or inaccurate pass) was expressed by binary logistic regression (Landau & Everitt, 2004). Method of backward stepwise selection was used to find the best model. The regression coefficients were estimated utilizing the maximum likelihood estimation method. To interpret the parameters of the model the odds ratios (OR) and their 95% confidence intervals were calculated. The statistical significance of the regression coefficients was verified by Wald's test. Reference category was set as the first option of the independent variable. All statistical tests were evaluated on the level of statistical significance $\alpha = 0.05$. Statistical software IBM SPSS Statistics 24 (IBM Corp., Armonk, USA) was used to compute these tests.

Results

Tab. 1 presents the distribution of the relative frequencies of the individual variables in all 5 games. Saturated model with all predictors (independent variables) was eliminated by insignificant predictor in each step. Statistical significance of each regression model was verified by likelihood ratio test. Saturated model with all four predictors was reduced by about 3 predictors in 4 steps. Wald's test showed statistical significance of one regression coefficients in the final model, and it was defensive pressure. Standardized beta weights (B), standard error of the estimate (SE), values of Wald's test (Wald), the statistical significance of regression coefficients (p value), odds ratio (Exp (B)), and the 95% confidence intervals (CI) are presented in Tab. 2. Based on the results we may state that for passing performance under medium defensive pressure is 2.376 times (95% CI; 1.125-5.017) greater chance for an inaccurate pass when compared to passing performance under low defensive pressure. If the passing is performed under high defensive pressure the chance for inaccurate pass increased 10.691 times (95% CI; 4.54-25.175) when compared to passing under low defensive pressure.

Table 1. Frequencies of variables

Variable	Description	Frequency [n]	Percent [%]
Dependent variable			
Passing performance	Accurate	378	83.8
	Inaccurate	73	16.2
Independent variables			
Defensive pressure	Low	382	84.7
	Moderate	44	9.8
	High	25	5.5
Ball possession duration	0–8 s	226	50.1
	9–16 s	205	45.5
	17–24 s	20	4.4
Intensity of load	<85% of HR_{max}	58	12.9
	85-95% of HR_{max}	337	74.7
	>95% of HR_{max}	56	12.4
Period	1^{st}	106	23.5
	2^{nd}	114	25.3
	3^{rd}	135	29.9
	4^{th}	96	21.3

Table 2. Variable included in the final model

		B	SE	Wald	df	p value	Exp(B)	95% CI for Exp(B)	
								Lower	Upper
Step 4	Defensive pressure			31.641	2	.000			
	Defensive pressure(1)	.865	.381	5.148	1	.023	2.376	1.125	5.017
	Defensive pressure(2)	2.369	.437	29.405	1	.000	10.691	4.54	25.175
	Constant	1.964	.156	158.984	1	.000	.140		

Discussion

Refoyo, Sampedro, & Sillero (2009) state statistically significant relationship between the realization of individual offensive skills (in game-based drills 1 vs. 1, 2 vs. 2, 2 vs. 1, and 3 vs. 2) and intensity of load. The successfulness of offensive skill realization was 68.1%, 62.2%, and 61.6% with the low, medium and high intensity of load, respectively. When the intensity of load increased the precision of offensive skills decreased. Lyons, Al-Nakeeb, & Nevill (2006) were focusing on the effect of total body fatigue on the accuracy of passing using a standardized passing test. Basketball players took part in this test under these three conditions: a relaxed state of the organism (after no load), after medium load, and after the maximal load of the organism. They found out the statistically significant differences in test's score between minimal and maximal load. These findings are different from our results. Difference between accuracy of offensive skills performed after the minimal, medium and maximal intensity of load (fatigue) can be different depending on external conditions (standardized test, practice, game). In a standardized test, it is possible to assess only one offensive skill and in practice, it is very hard to create conditions mirroring those of a real game, where we have to take into consideration also other contextual factors (opponent, emotions, etc.). Vencúrik (2016) also shows that the intensity of load is an insignificant factor in shooting performance. Csataljay, James, Hughes, & Dancs (2013) and Vencurik & Nykodym (2017) confirm the influence of high defensive pressure on shooting performance. This outcome is in accordance with our results and documents the influence of defensive pressure on individual offensive skills under real game conditions. On the other hand, it shows us the importance of this factor when developing the offensive skills.

Conclusion

Based on this study, if the aim is to further develop player's skills, we recommend coaches to create drills where the passing is performed under the medium or high defensive pressure. On the other hand, the motivation of defensive players to make medium or high pressure during practices is also needed. Nevertheless, for future research, it is recommended to increase the number of analyzed passes in more games performed by more players.

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SPORT AND SOCIAL SCIENCES

REIMAGINING TOPICAL CHALLENGES WITHIN THE KINANTHROPOLOGICAL FRAME

Hurych Emanuel
Faculty of Sport Studies, Masaryk University

Abstract

This paper traces some topics which to may become urgent in the few next years for all those who are engaged in kinanthropology within the Euro-American cultural zone. We selected three topics which should be seriously considered as influential processes in the field of sportification, technologization and physical inactivity.

Within the theoretical frame of this paper we describe a core of these three phenomena and their ambivalent effects on modern human society. We argue a conceptual schema in which these processes are interconnected in some way and in which they influence each other in quite a multiple pattern.

Some aspects of these processes can be understood as problems to be solved, despite their positive and negative effects in the social field. In our opinion, some conventional methods of solving the negative effects of these processes often fail because they are based on a unilateral approach coming from a specific branch of study.

We propose a more multiple approach, established on the specific interconnection of the philosophical, sociological and psychological perspectives. In the synergy of these perspectives we can find some new possibilities for a deeper understanding of the causes and consequences of sportification, technologization and physical inactivity in the kinanthropological frame.

In this way, we can transform these processes (including some problems which they bring) into urgent challenges for social studies in kinanthropology. The necessity to reconstruct a traditional portfolio of the most important kinanthropological issues comes from the rapid development of our society at the end of the 2010s.

Reimagining this portfolio also supports the role of social studies in sport, which has been somewhat suppressed recently in scientific research, because of the rapid development of the precise outputs provided by sciences, sport medicine and economic studies in kinanthropology.

Key words: *sportification, technologization, physical inactivity, synergistic approach*

Introduction

Kinanthropology is quite a new scientific discipline which covers a broad space within social studies in different approaches. Bohuslav Hodaň in his concept of socio-cultural kinanthropology speaks about division of kinanthropology into certain subdisciplines such as developmental and structural kinanthropology, biological kinanthropology, pedagogical and psychological kinanthropology, economical kinanthropology, philosophical kinanthropology and socio-cultural kinanthropology (Hodaň, 2006, 30–31).

There are other different models used in some contexts, but for our reasons we focus not on the structural aspects of this discipline but rather on its content. The basic frame of this discipline is made by an interest in the 'moving person', in the meaning of a physically active kind of human motion, including the individual and social consequences of this process. Here we should mention that this is a more general concept, and that the other (narrow) focus is laid on more specific kinds of movement, like doing physical exercises, or even doing sports (ibid., 29).

The modern concept of kinanthropology in the Czech Republic was established during 1990s, coming from the previous model of theory of physical culture (ibid., 11–15). While the terminological and structural conception of this discipline went through some corrections and innovations, the content was understood as permanent for many years – laid on the historical focus of the discipline.

However, we can notice many changes in the sphere of human movement. Many of them are caused or (at least) accompanied by rapid technological developments and by social changes in the Euro-American cultural zone.

This paper deals with some topics that may become urgent in the few next years for kinanthropological research. We argue for the reimagining of priorities of social studies within the kinanthropological frame, to include some concrete challenges which ought to be seriously considered as influential processes in the field of kinanthropology.

There are three specific phenomena described and examined in this paper: sportification, technologization and physical inactivity. Besides some analyses of their nature, as well as their positive and negative effects, we would like to focus on the mutual relationships among them and on some of their characteristics in a structural model.

An elementary description of the selected phenomena

The nature of three selected processes can only be described here in a basic and brief form because of the limited space for this explanation within this paper.

Sportification is a specific phenomenon which has been studied by a great range of authors (e. g. Von Der Lippe, 1994; Pfister, 2007; Sato, 2013; Tuckett, 2016) in the context of some concrete sports. As a more general social problem, sportification has been examined rather later, since 2010. From different viewpoints it was dealt by different authors (Vlieghe, 2013; Jirásek & Kohe, 2015; Hurych, 2015).

Ivo Jirásek described this term as a process of adopting cultural examples and symbols from sport life and their importationinto a broader conceptual context in different cultural areas (Jirásek, 2005, 66). We can also argue that the core of this phenomenon consists in bringing some principles, rules and methods which are essential in the world of sport into our everyday life. That means to apply something which is quite permanently established and present in the sport sphere into completely different areas of our activities (education, science, politics, family life etc.).

Concerning the positive effects of this process we can mention respect for rivals, 'the art of losing', keeping transparent rules and applying fair play principles. Negative effects are presented by over-competitiveness, an excessive effort for comparability (quantification), and inappropriate rivalization as one of the two main factors of sport motivation according to Lipiec (1999).

Technologization is presented by the implementation of new technological developments into our everyday lives. The specific attention of this (quite long-time) process is called by the completely reconstructed value of information these days. The positive sides are evident (unavoidable progress of mankind, growing economic and cultural developments etc). Some warnings from possible negative effects have been provided by many philosophers, sociologists and scientists (Martin Heidegger, Erich Fromm, Konrad Lorenz, etc.) even in the times when human dependence on technologies was not as strong as today. Some concrete dangers are the trend towards the domination of the form over the content, rising time demands on following the innovative processes within IT, new dangers in cyberspace (e. g. hacker attacks), or the loss of abilities to live and work without certain technological instruments, like internet, mobile phones, or GPS technologies.

Physical inactivity is a typical symptom, visible primarily in the economically well-developed countries. Many authors describe a sedentary way of life as a typical product of the social structure in some societies (Sekot, 2015). Desires for higher comfort levels and an easier life-style are typical for all stages of human development. However, the illusive character of desires of this type is obvious. Human biological determination is connected with the development of our physical abilities (which is evident in the ontogenetic context). Health risks coming from physical inactivity (high blood pressure, obesity, diabetes mellitus 2 etc.) are examined in detail within sport medicine. They are connected with progressive decrease of general resistance against diseases, lower adaptability and lack of ability to survive in difficult conditions, which arises from a loss of general motor abilities and specific motor skills.

However, there are some other important effects of the rising levels of physical inactivity not so closely related to health. Here we can speak about a complex reconstruction of system of values with respect to the role of movement in human life

What has to be mentioned here, is a major difference between sportification and technologization, which plays an important role in the structure of relations which we offer in the next part of this paper. On the other hand, this difference in the character of the phenomena do not necessarily present an obstacle for establishing the proposed structural model because all of these phenomena can be understood either as processes, or as results of processes according to their temporary stage.

The structural model of relations within the selected phenomena

We found 9 links of different characteristics concerning the above described phenomena. This overview is not complete, there can be found some other links as well but we do not consider them to be relevant for our study. The selected ones are included in Fig. 1.

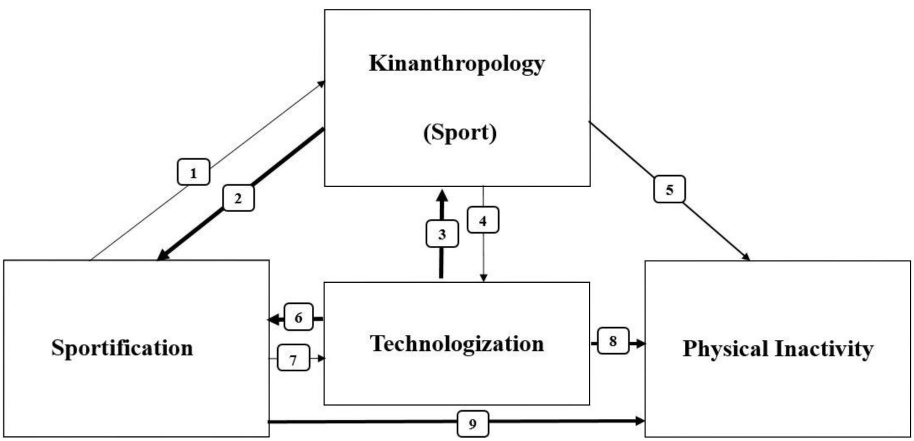

Figure 1. The proposed structural model

Before we can start examining some aspects of this simple model, we should provide some basic characteristics of these relations in the form of their technical description. While the directions are included in the scheme itself, the other aspects have to be described in the next steps. We focused on these parameters: strength of the link, their increasing or decreasing influence (in general) and some basic verbal characteristics. These aspects are displayed in Fig. 2.

link nb.	*strength of the link*	*influence*	*short verbal description*
1	**weak**	**increasing**	**transmiting different kinds of competitivness into kinanthropology/sport**
2	**high**	**increasing**	**transfer of kinanthropological/sport phenomena into a more general context**
3	**high**	**increasing**	**technologies which are changing the face of sport (changing rules, new sport disciplines etc.)**
4	**weak/ middle**	**increasing**	**general technological developments enabled by sport development**
5	**middle**	**decreasing**	**kinathropology/sport should go against physical inactivity**
6	**high**	**increasing**	**techological developments support sportification**
7	**middle**	**increasing**	**sportification calls for new instruments**
8	**high**	**increasing**	**technologies support (enable) rising physical inactivity (PI)**
9	**high**	**ambiguous**	**complicated and non-linear link; sportification decrease PI but not always**

Figure 2. Some selected aspects of the followed links

Remembering the note that all three examined phenomena can be understood as general socio-cultural problems (it does not mean that their influence and results should be understood just as negatives), we prefer to select some of the links which can be interesting in this context. That is why our proposal of new challenges for kinanthropology is based on two complementary conditions.

One comes from the relation between the three phenomena and kinanthropology (as seen in Fig 1 and 2). The other is based on the impact of those phenomena on a broad socio-cultural sphere. The role of kinanthropology is important in this process and studying it presents one of the goals of the whole concept. Not just technologization, but also sportification and physical inactivity present a very general issue connected not just to kinanthropology. However, our aim is to focus the model on those parts which can be examined in the frame of kinanthropology. Fig. 3 displays the relations of the selected phenomena to the general socio-cultural sphere and to the position of kinanthropology here.

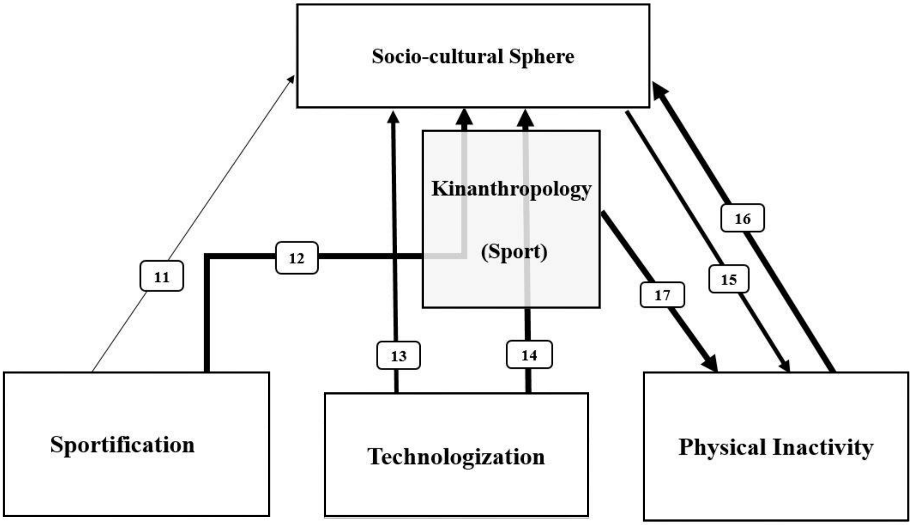

Figure 3. Relations to the socio-cultural sphere

The main aim of this paper is to bring a structure displaying possible links. The more detailed description of the links and their examination presents a topic for some future studies. However, an important note should be made at this place: It is quite difficult to explain some of the links separately. For instance, the Links 16 and 17 are interconnected in a remarkable matrix of sub-relations. In spite of this fact, considering limited space for presenting our concept within this paper, we selected for the next explanations just the Link 12. All these explanations are intended as illustrative– they should help the reader to understand the meaning of the structural model, generally. Developing more sophisticated examinations will need much more work within long-time studies.

Some selected links to the socio-cultural sphere

The major reason why we have selected Link 12 for the explanation of the proposed structure consists in the fact that some relations are very obvious and understandable here. Considering sportification as a process of bringing some elements (or more complex units) from their natural settings, which is the world of sport, into the broad socio-cultural sphere, we may find some specific examples where sportification penetrates to everyday life of modern society directly, not via the kinanthropological scene. This is the case of the Link 11. For instance, (at least in the Czech language) quite often used phrases like the 'sportive approach to life' or the 'sportive approach to sexual relations' do not evince the direct connections to kinanthropology. In fact, there are some common roots here, but the meanings were transmitted too far from this connection.

However, the core of the phenomenon of sportification consists in the processes which are related to kinanthropology (or sport in a narrow perspective) in both directions. To explain it, we should remind ourselves of Link 2 (Fig. 1) in which kinanthropology saturates sportification. It means that kinanthropology provides some 'material' (rules, methods, approaches etc.) which enable sportification to grow. Then the strongest stream of sportification influences flows through kinanthropology (sport) to the socio-cultural sphere (Link 12).

Some sources of this development consist in rapid changes in social structures. The deeper roots can be found in the loss of some traditional values. Our modern society loses some pillars of the former significance. In this context two of them can be mentioned – the complex of humanistic education and religion.

A complex humanistic education is more and more overshadowed by technical and nature sciences. This supports the position of technologization, and consequently the influence of technologization to sportification (the Link 6). The loss of religion in a process of secularization (which is very strong in Czech society) brings the call for some different (non-religious) forms of spirituality. One of the fields which provide possibilities for spiritual approaches can be also sport (Parry et al., 2007; Parry et al., 2011), or even a broader concept of kinanthropology (Hurych et al., 2013).The situations in which sport adopts a role of something like a 'new religion' were also described as well as in implicit or the explicit form by different authors (e. g. Bain-Selbo & Sapp, 2016).

Here we can see one of the influential purposes for strengthening the role of sportification in our society. If sport becomes an important kind of means of how to compensate modern people´s deficits in losing religion and losing a system of values, then the transmission of any sports phenomena to our everyday lives becomes more frequent and more complex.

Another important factor of the examined processes can be presented by the very strong interconnections between sportification and technologization (Links 6 and 7) and by the penetration of technologization into kinanthropology (Link 3).

Examining the directions and the nature of the links can provide us an instrument to understand better the logic of the processes of sportification and technologization and the reasons for some multiplication effects which can be observed, including concerning their influence into the status of physical inactivity.

Conclusions

We have proposed a general structural model of relations among three selected phenomena – sportification, technologization and physical inactivity. We discovered/generated some links which present a possibility of how to approach this complex and ambiguous system of phenomena and their mutual influences.

The characteristics of the links must be examined more in detail. We argue that some of them can be investigated as the separate problems but the majority of them can be understood just as the parts of a more complex issue.

For this reason, we propose to apply a synergistic approach to the problem, using all the philosophical, sociological and psychological discourses. The reason for preference of this multidisciplinary, interdisciplinary and transdisciplinary solution is done by the above-mentioned character of the problem: a complex nature of all the examined phenomena and quite complicated links in the structural relation model. On the other hand, we argue that the basic platform which enables the development of methods to solve the problem should be the philosophical discourse.

A common aspect connecting sportification and technologization is the increasing instrumentality of approaches to the urgent problems in our society and the increasing preference for instrumental ways of solving these problems. This trend can be very risky, at least in the unilaterality of these solutions and in neglecting the holistic character of all the examined problems.

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SOCIOECONOMIC FACTORS OF PHYSICAL ACTIVITY OF PERSONS IN THE OLDER PRODUCTIVE AGE FROM BIG CITY ENVIRONMENT

Puciato Daniel[1], Oleśniewicz Piotr[2], Markiewicz-Patkowska Julita[3], Widawski Krzysztof[4]
[1] Faculty of Physical Education and Physiotherapy, Opole University of Technology, 76 Prószkowska Street, 45-758 Opole, Poland, d.puciato@po.opole.pl, +48 77 449 80 00
[2] University School of Physical Education in Wrocław, Poland, al. I.J. Paderewskiego 35, 51-612 Wrocław, Poland, piotr.olesniewicz@awf.wroc.pl
[3] WSB University in Wrocław, ul. Fabryczna 29-31, 53-609 Wrocław, Poland, julita.markiewicz-patkowska@wsb.wroclaw.pl
[4] Univeristy of Wrocław, Institute of Geography and Regional Developmnet, Poland, Uniwersytecki Sq. 1, 50-137 Wrocław, krzysztof.widawski@uwr.edu.pl

Abstract

Physical activity is an important component of healthy lifestyle that contributes to improvement of physical fitness and capacity and health. The paper aims to assess relations between physical activity and socioeconomic status of persons from the age groups 55-65 from Wrocław. The studies involved 1008 persons, including 554 women and 454 men, while for assessment of habitual physical activity short form of IPAQ was applied. Moreover, information on selected socioenomics factors of subjects were obtained. The study shows that 60.8 % of surveyed women and 68.1 % of men have performed physical activity at level sufficient for obtaining positive health effects. Statistically significant socioeconomic modifiers of physical activity of subjects from Wroclaw were the following: sex, level of education, professional status, marital status and indebtedness. The dependence between physical activity and income per capita and savings were not statistically significant. In the view of obtained results, it was suggested it is necessary to include people of older productive age in public health programmes focusing on among others increasing level of physical activity.

Key words: *Physical activity, WHO, Socioeconomic factors, Big city environment*

Introduction

Physical activity is an important component of healthy lifestyle, while its deficiency (hypokinesis), apart from decrease in physical fitness and capacity [25, 38, 42, 43] is related to increase in risk of such diseases as: muscle atrophy, osteoporosis, type 2 diabetes, hypertension, coronary disease and some types of cancer [2, 13, 17, 24, 27, 28, 30, 41]. The literature documents also negative effects of hypokinesis on mental health and mental acuity: disruption of cognitive functions, increased levels of anxiety and depression, decreased well-being and self-esteem, decreased self-efficacy, increased stress and decreased sleep quality [18, 21, 31, 40].

Undertaking physical activity is extremely important for people of older productive age, as it allows them to maintain their functional and intellectual performance at level allowing them to effectively perform professional work. This is especially important in terms of socio-demographic phenomena in highly developed countries, i.e. increase in the average life expectancy, increasing percentage of people of older age, changes in retirement legislation (increasing retirement age) or change in lifestyle of older people involving desire to live actively and creatively [36, 39]. Moreover, the results of empirical studies indicate that performing physical activity by persons of older age may assist in: increasing chance for positive adaptation to old age, maintaining high quality of life, including physical fitness and capacity as well as keeping satisfying family and social contacts [12, 15, 22, 23, 26, 32, 37, 44].

However, obtaining positive effects of physical activity is related to its sufficiently high level. The World Health Organisation recommends to that end at least performing physical effort of moderate intensity for 150 minutes, or of high intensity for 75 minutes a week. Such type of physical activity should also be stacked in minimum 10 minute long periods [45]. However, empirical studies show that satisfying these standards is especially difficult for older people, as a level of physical activity often decreases with age [19, 36, 39]. On the other hand, level of physical activity is not only age-dependent but depends on many other factors, i.e. socioeconomic status.
Physical activity is not only a biological phenomenon, but also a cultural one and thus may be affected indirectly by such factors as: sex, education, marital status, professional and economic status. Although the literature quite well shows relations between physical activity and social factors [3, 7, 14, 16, 19, 26, 35, 44], the effects of economic status on physical activity remain unknown. On the one hand, less affluent people often perform professional work of physical nature, on the other, more affluent persons are usually better educated, which may be related to higher awareness of importance of healthy lifestyle, including physical activity, for health [8, 14, 35]. Moreover, increasing number of types of physical activity is nowodays payable,

which gives better position to people of good economic status. The results of previous empirical studies analysing relations between physical activity and economic status were not conclusive. In articles, Biernat [4] and Choi et al. [8] show increase in physical activity with improving economic status, while results of studies by Chen et al. [6], Da Silva et al. [9] and Puciato [34] indicate multidirectional correlations between physical activity and economic status.

The previous works also rarely analyse socioeconomic conditions of physical activity in people of older productive age, usually focusing on the entire population or considering this issue for younger people. Overcoming this research gaps is the most important objective of the article, which aims to assess relations between physical activity and socioeconomic status of persons from the age groups 55-65 from Wrocław, Poland. The paper poses the following research questions:

1. What is a percentage of surveyed people performing physical activity to an extent sufficient for obtaining positive health effects?
2. Does such socioeconomic factors as: sex, education, marital status, professional status, income, savings or indebtedness are related to the level of satisfying recommendations of physical activity bringing health benefits?

Methods

The surveys for the paper were conducted in November 2014 in Wrocław, Poland. The studied material involved 1008 persons (554 women and 454 men) of age 55 to 65, which corresponds to approx. 1% of people of this age living in Wrocław. Quota sampling was used, which involved: (1) determination of control quotas of population characteristics – sex and age and groups (quotas) of population elements corresponding to the structure of Wrocław community, (2) the determined quota were divided among the pollsters, which were students trained for conducting questionnaire surveys. All the respondents were informed about the survey aim and procedure and agreed to participate in the survey. A detailed characteristics of respondents as per socioeconomic variables is presented in Table 1.

Table 1. Socioeconomic characteristics of 55-65 y.o. respondents

Variables	n	%
Sex		
Female	554	55.0
Male	454	45.0
Education level		
Primary and basic vocational	518	51.4
Secondary	300	29.8
Higher	190	18.8
Professional status		
Blue-collar worker	220	21.8
White-collar worker	379	37.6
Private operator	98	9.7
Stay-at-home	128	12.7
Unemployed	183	18.2
Marital status		
Free	156	15.5
Married	852	84.5
Monthly income per capita in household		
Up to 250 €	375	37.2
250-500 €	465	46.1
Above 500 €	168	16.7
Savings		
Yes	683	67.8
No	325	32.2
Indebtedness		
Yes	356	35.3
No	652	64.7

Habitual physical activity was assessed by means of diagnostic survey with auditorium questionnaire technique. Short form of IPAQ containing six questions regarding physical activity of respondents in typical week of their [20] was used as a survey tool. The used tool is commonly used in population studies [1, 10]. The activity considered in studies included both physical activities performed at work, at home and its surroundings, during transportation from place to place as well as in a free time. The article analyses in detail answers regarding self-assessment of frequency and duration of physical activities of three intensity groups: high, moderate and low. The effort intensity was described using metabolic equivalent (MET – 1 MET corresponds consumption of O_2 at rest and is equal to 3.5 ml O_2/kg of body weight/min) with 3.3 MET meaning low intensity effort, 4 MET for moderate effort and 6 MET for intense (high) effort. The calculations involving multiplication of number of days, duration and listed values of metabolic equivalent separately for each group of intensity effort. The collected information enabled comparison of physical activity parameters declared by respondents from Wrocław with values recommended by the World Health Organisation [45]. The paper treats as people meeting health recommendations the respondents that satisfy at least on of the criteria described in the introduction (WHO yes), while as people performing physical activities below extent providing health benefits, respondents that did not meet any of the criteria.

During the research we collected also data on selected socioeconomic factors, i.e.: sex (male, female), education level (basic vocational, secondary, higher), professional status (blue collar, white collar, private operator, stay-at-home, unemployed), marital status (free, married), monthly income in the household per person (up to 250 Euro, 250-500 Euro, above 500 Euro) and with savings (yes, no) or debt (yes, no).

The paper involved calculation of basis statistical characteristics, i.e. mean averages, standard deviation, variation coefficients and extreme values (minima and maxima). The significance between groups distinguished by sex were estimated using non-parametric Mann-Whitney U test and χ^2 test. For assessment of relations between physical activity and socioeconomic factors logistic regression (odds ratio statistics – OR) was applied. Statistical inference was conducted for assumed *ex ante* probability level of $p<0.05$. The calculations were performed using computer software IBM SPSS Statistics 20. Research project received a positive opinion of the ethics committee at the University of Physical Education in Wroclaw.

Results

Respondents 55 to 65 y.o. of both sexes most often undertook physical activity of low intensity. On average they performed physical activity 4.9±1.5 per week (males) and 4.7±1.3 (females). Physical effort of moderate intensity were performed by female respondents on average 3.6±1.6 per week, while male ones – 3.5±1.2. The respondents were least likely to perform high intensity efforts: i.e. 3.1±1.5 per week for women and 3.3±1.5 per week for men. The difference between frequency of intensive physical activity by female and male respondents were statistically significant in favour of the males ($p<0.005$).

Average duration of physical activity for females was highest for high intensity physical efforts (70.4±33.9 minutes), while for male the longest average duration corresponded to moderate physical activity (77.1±43.8 minut). While, the representatives females and males performed their low efforts for 64.1±41.3 minutes and 65.2±34.5 minutes, respectively. Statistically significant differences ($p<0.005$) between duration of physical activity in females in comparison with males in favour of the males were observed for physical activity of moderate intensity.

The greatest average weekly energy expenditure was connected with performance of high intense physical acitivity: 1766.3±1281.1 MET min/week for females and 2010.2±1542.5 MET min/week for males. While the lowest for females was connected with physical activity of moderate intensity (1016.4±718.4 MET min/week), and for males – low intensity (1063.4±762.7 MET min/week). Statistically significant differences ($p<0.05$) between weekly average energy expenditure in both sexes in favour of males were observed for high intensity efforts (Table 2).

Table 2. Variations of physical activities between sexes for 50-64 y.o. respondents

Variables	Females		Males	
	$\bar{x}$	SD	$\bar{x}$	SD
Weekly frequency of vigorous physical activity [days/week]	3.1	1.5	3.3	1.5*
Weekly duration of vigorous physical activity [min/day]	70.4	33.9	73.9	39.6
Weekly energy expenditure of vigorous physical activity [METmin/week]	1766.3	1281.1	2010.2	1542.5*
Weekly frequency of moderate physical activity [days/week]	3.6	1.6	3.5	1.2
Weekly duration of moderate physical activity [min/day]	69.9	37.1	77.1	43.8*
Weekly energy expenditure of moderate physical activity [METmin/week]	1016.4	718.4	1102.9	821.4
Weekly frequency of low physical activity [days/week]	4.9	1.5	4.7	1.3
Weekly duration of low physical activity [min/day]	64.1	41.3	65.2	34.5
Weekly energy expenditure of low physical activity [MET min/week]	1099.4	938.0	1063.4	762.7

* – statistically significant difference $p < 0.05$

The assessment of physical activity of surveyed 55 to 65 y.o. Wroclaw residents shows that 60.8% of female respondents and 68.1% of male respondents satisfied recommendations of the World Health Organisation. While the physical activity level in 39.2% of female respondents and in 31.9% male respondents were insufficient to obtain potential health benefits. The surveyed males statistically significantly performed more frequently physical activities at level recommended by the WHO (Figure 1).

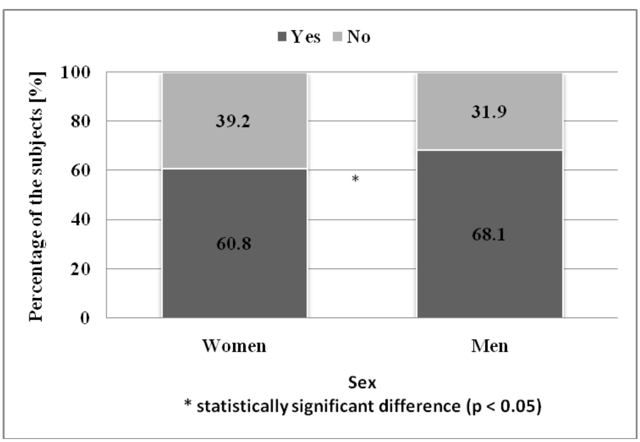

Figure 1. Level of satisfying WHO recommendations for healthy physical activity by respondents aged 50-64 y.o.

The analysis of relations between physical activity and socioeconomic status of the respondents from Wroclaw showed that the following modifiers of physical activity are statistically significant: sex, level of education, professional status, marital status and indebtedness, while dependences between physical activity and income per capita and savings proved to be not statistically significant.

As already mentioned, the majority of both males and females declared taking physical efforts that according to the World Health Organisation allow to achieve health benefits from physical activity. Based on analysis of odds ratio we may conclude that probability of satisfying WHO recommendations by surveyed males was almost 40% higher than for surveyed females (OR = 1.37, 95% CI: 1.06–1.78). Analysis of dependence between physical activity and education of respondents allows the conclusion that 77.7% respondents with secondary education, 58.9% with higher education and 58.1% with primary and basic vocational education are people performing sufficient physical activity in terms of health benefits. Moreover, results of logistic regression prove that odds for satisfying WHO recommendations were highest for surveyed Wroclaw residents with secondary education, while the lowest for people with primary and basic vocational education. The probability of performing high physical activity by persons with secondary education was 2.5 times higher than by persons with primary and basic vocational education (OR = 2.51, 95% CI: 1.82–3.46). While considering professional status of respondents it was found that greatest percentage of persons meeting recommendations of the World Health Organisation was for unemployed (69.4%) and blue collar workers (69.1%), while the lowest for stay-at-home group (53.1%). For private operators, this percentage was 63.3%, while for white collar workers – 62.5%. Chance of performing healthy physical activity in stay-at-home persons was therefore almost 2 times lower (OR = 0.51, 95% CI: 0.32–0.79), while in white collars (OR = 0.75, 95% CI: 0.52–1.06) and private operators (OR = 0.77, 95% CI: 0.47–1.27) lower by over 20% than for unemployed and blue collars. Another modifier of physical activity of the respondents proved to be their marital status. More than 4/5 of the surveyed Wroclaw residents aged 55 to 65 y.o. in free status taken physical activity of appropriate frequency and duration, while for persons in relationships this percentage was 60.9%. Odds for meeting physical activity standards by persons in relationships were almost 3 times lower than for persons of free status (OR = 0.36, 95% CI: 0.23–0.55).

For economic status, only significant modified or physical activity of Wroclaw residents proved to be the fact if they are indebted or not. Only slightly more than half (54.5%) of indebted persons performed sufficient physical activity in terms of potential health benefits. Among persons without debts, this percentage was 69.3%. The probability of meeting WHO standards by people without debt was higher by almost 90% than for indebted persons (OR = 1.89, 95% CI: 1.45–2.46). Despite lack of statistically significant correlation between physical activity and other economic variables (income per capita and savings) it was found that the highest percentage of respondents performing sufficient physical activity was among persons of highest income and with savings (Table 3).

Table 3. Relations between socioeconomic variables and physical activity of 50-64 y.o. respondents

Variables	WHO Yes n	%	No n	%	p	OR	CI -0.95%	0.95%
Sex								
Female	337	60.8	217	39.2	0.017	1.00	–	
Male	309	68.1	145	31.9		1.37	1.06	1.78
Education level								
Primary and basic vocational	301	58.1	217	41.9		1.00	–	
Secondary	233	77.7	67	22.3	0.000	2.51	1.82	3.46
Higher	112	58.9	78	41.1		1.04	0.74	1.45
Professional status								
Blue-collar worker	152	69.1	68	30.9		1.00	–	
White-collar worker	237	62.5	142	37.5		0.75	0.52	1.06
Private operator	62	63.3	36	36.7	0.019	0.77	0.47	1.27
Stay-at-home	68	53.1	60	46.9		0.51	0.32	0.79
Unemployed	127	69.4	56	30.6		1.01	0.66	1.55
Marital status								
Free	127	81.4	29	18.6	0.000	1.00	–	
Married	519	60.9	333	39.1		0.36	0.23	0.55
Monthly income per capita in household								
Up to 1000 PLN	241	64.3	134	35.7		1.00	–	
1001-2000 PLN	290	62.4	175	37.6	0.369	0.92	0.69	1.22
Over 2000 PLN	115	68.5	53	31.5		1.21	0.82	1.78
Savings								
Yes	447	65.4	236	34.6	0.192	1.00	–	
No	199	61.2	126	38.8		0.83	0.63	1.10
Indebtedness								
Yes	194	54.5	162	45.5	0.000	1.00	–	
No	452	69.3	200	30.7		1.89	1.45	2.46

Discussion

The majority of respondents from Wroclaw of older productive age satisfied standards of physical activity recommended by the World Health Organisation. Similar results were observed in previous studies of Wroclaw population [34], while the lowest percentage of physically active population was found in Katowice population [36]. While the studies conducted for general Polish population by Gerovasili et al. [16], sufficient physical activity (in terms of positive health effects) was observed only in 56% of respondents.. These studies showed that Polish are one of the least active physically nations, as the average value for European Union residents was 71.4%. The own studies confirmed prior findings involving: higher activity in men in comparison with women [11, 29, 38] and predominance of low and moderate intensity in structure of physical activity of respondents [4, 28, 35]. Therefore, the obtained results are on the one hand promising as they suggest that physical activity performed by respondents will allow them to improve or maintain their health, while on the other, it is worrying as almost 40% of females and over 30% of males had too low physical activity. The results obtained in this work are worse than average for EU countries in the already referred to studies by Gerovasili et al [16]. It shall be noted that representatives from big city populations are generally more active physically than residents of small towns and villages [19, 39]. Therefore, one can assume that percentage of person performing sufficient physical activity in terms of health requirements among Polish is in general lower than in surveyed Wrocław residents.

Next to sex, statistically significant predictors of physical activity of respondents from Wroclaw proved to be such socioeconomic factors as: education, professional status, marital status and indebtedness. In case of education, the highest chance for meeting WHO standards was for respondents with secondary education. This is confirmed by the fact already shown in the earlier studies [5, 35] that secondary education is related to sufficient awareness of importance of physical activity for health. In this view, it must be noted that there is rather low percentage of people satisfying required physical activity among respondents with higher education. This may be due to their professional work, which is usually of intellectual nature and does not involve performance of physical effort. This is confirmed by phenomenon observed of own studies of rather low physical activity of white collar workers, for whom probability of meeting the WHO recommendation was lower by 25% in comparison with blue collar workers. Similar results were obtained by: Biernat [4], Choi et al. [8] and Puciato et al. [36]. Moreover, as studies by Chinna et al. [7] show that greatest barrier of undertaking physical activity by well-educated persons are endogenous and related to such factors as motivation and free time. Poland is a dynamically developing country, which, however, has to catch up with the past negligences. The current state of this development causes work productivity and wages to increase relatively quickly, which causes that in large group of employees may occur substitution effect of wage increase. This involves that higher wage encourages employees to increase number of working hours at the expense of free time. As a consequence it is replaced with work time, which may be aggravated in considered group of respondents by need to compete with younger employees. In case of professional status, next to physical workers, the greatest chance to satisfy standards of physical activity was found for unemployed. This may be a result of large amounts of available free time and part of which may be used for physical activity, however this is not consistent with results of other authors, i.e. Chen et al. [6] and Puciato et al. [36], thus requires further in-depth studies. The lowest percentage of physically active persons in stay-at-home group is a result of the fact that in Polish conditions those are usually females, who, as was shown, have lower physical activity in comparison with males. Moreover, quite a common pastime, especially for middle-aged and older women are passive forms of spending time, reading press and books, meeting with friends and family or participation in religious ceremonies. The analysis of marital status of respondents indicates that definitely higher probability of fulfilling recommendations of physical activity occurs for persons of free status, than for people in relationships. Similar results were obtained by Choi et al. [8], Puciato [34], Schneider and Becker [39] and da Silva Garcez et al. [9]. This may be caused by the fact that such persons usually have greater amount of free time, as they can decide freely about their lives. Moreover, lifestyle of people living alone is often connected with high individualism and willingness for self-development, also in the field of health, physical fitness and appearance.

The indebtedness was an only economic factor that significantly modified physical activity of the respondents of older productive age. The chances for performing sufficiently intense physical activity in persons without debt were almost 90% higher than for indebted persons. In the Polish socio-economical reality, indebtedness of 55 to 65 y.o. people is often a result of taking mortgage for themselves or their children. In the current economical conditions that involves large fluctuation of currency exchange rate, paid instalments may greatly limit financial capacities of Polish households, including using payable forms of motor leisure. As a consequence, there is also a need to get second job, which reduces available free time and disturbs proper relations between work and leisure. Such a situation may increase stress level and cause psychosomatic illnesses, thus decreasing interest in physical activity, which as outlined in the introduction can even more aggravate these symptoms. This is even more worrying if one considers that the risk of developing such illness increases with age. In the view of obtained results, it was suggested it is necessary to include people of older productive age in public health programmes focusing among others on increasing level of physical activity.

The analysis of conducted studies allows to indicate strengths and weaknesses of the paper. The strengths may include surveyed group, as the analysis of conditions of physical activity in people of older productive age was rarely conducted previously. Another strength of the article is assessment of economic status of the respondents not only in terms of income, as in papers by: Biernat [4], Choi et al. [8] and da Silva Garcez et al. [9], but also in terms of such variables as savings and indebtedness. While the weaknesses included limiting surveyed population to Wroclaw residents and application of indirect method of assessment of physical activity. Therefore, further studies shall include increasing spatial extent to the entire Poland and other European countries and involvement of also other methods for studying physical activity (e.g. IPAT in long form, pedometry or accelerometry).

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THE EDUCATION OF SOCIAL SKILLS AMONG SENIOR HIGH SCHOOL AGE STUDENTS IN PHYSICAL EDUCATION CLASSES

Akelaitis Arturas
Lithuanian university of educational sciences, Vilnius, Lithuania

Abstract

The purpose of this study was to reveal the peculiarities of the education of social skills among senior high school age students in physical education classes. Study hypothesis – the application of education programme would allow expecting more developed social skills among senior high school age students in physical education classes. Participants in the study were 51 pupils of the ninth grade (15.15 ± 0.36). Experimental group consisted of 25 and the control group of 26 senior high school age students. Tromso Social Intelligence Scale (TSIS), Problem Solving Inventory (PSI), Jusupov's questionnaire of empathy level diagnostics, and General Trust Scale (GTS) were used. Repeated measures (RM) multivariate analysis of variance (2 × 2 (Group × Time) MANOVA) was used in order to analyse the effects of the educational program. It was found that during the educational experiment the applied measures of educational impact had a statistically significant effect on the components of experimental group senior high school age students' social awareness, empathy, problem solving, and trust in others skills in physical education classes.

Key words: *social skills, educational program, physical education classes, senior high school age.*

Introduction

Social development is the process in which an individual acquires essential skills as a member of a society (Gulay & Akman, 2009). Social skills are defined as socially acceptable, learned behaviours that enable an individual to interact effectively with others and to avoid or escape unacceptable behaviours that result in negative social interactions with others (Gresham & Elliott, 2008). Cooperation, collaborating with the others, problem solving, helping, initiating a relationship, requesting help, and trust in others are some examples of this type of behaviour. Learning the above behaviours and creating influential relationships with others is most important in adolescence. Unfortunately, some students do not learn these skills. Students who lack social skills may be excluded from positive interaction with peers and may have problems in relationships with their teachers, which can lead to the risk of poor academic achievement (Bloom et al., 2007). Students with poorly developed social skills mostly lack cooperation and communication skills, as well as the ability to respond positively to peers and the ability to develop friendships (Bilic Prcic, 2007).

The education of social skills is particularly important during adolescence because youth at this stage are going through rapid biological, cognitive, and physiological changes associated with puberty (Yurgelun-Todd, 2007). According to CASEL (2015), adolescents also engage in more risky behaviour than younger students and face a variety of challenging situations, including increased independence, peer pressure, and exposure to social media (e.g., „Facebook“, „Twitter“, or „LinkedIn“). As adolescents increasingly interact with peers, they must simultaneously contend with peer pressure. Teenagers also must navigate the vicissitudes of identity development and the search for purpose and meaning as they transition into adulthood (Erikson, 1993).

School physical education during childhood and adolescence has been associated with improvements in numerous physiological and psychological variables (Nichols, 1990). Physical education classes and other sport activities as a social environment play an important role in the lives of many adolescents (Trottier & Robitaille, 2014). Contemporary physical education, through its dynamic social nature and its different codes, provides a variety of opportunities for student interaction that requires performance of social skills such as self-control, goal setting, accepting, helping and cooperating with others (Hellison, 2011). Research evidence suggests that quality physical education contribute positively to students' social and moral development (Hellison & Martinek, 2006), fair play behaviour (Vidoni & Ward, 2009), team building, cooperation, and development of social skills (Hunter, 2006).

Study originality/meaning. In our country this study is one of few studies which address senior high school age students' education of social skills in physical education classes. In the context of physical culture and sports only middle school age students' social adaptation peculiarities during physical education classes (Klizas, 2010), basketball school students' social skills education peculiarities (Sniras, 2005) and young basketball players' self-efficacy and its education peculiarities (Brusokas, 2014) studies were carried out, however, there is lack of publications that would analyse by senior high school age students' education of social skills in physical education classes. Therefore, this study provides new knowledge of the education of social skills in the field of research.

Study hypothesis – the application of education programme would allow expecting more developed social skills among senior high school age students in physical education classes.

The aim of the study – to reveal peculiarities of the education of social skills among senior high school age students in physical education classes.

Research methods

Instruments. To determine senior high school age students' social skills in physical education classes following questionnaires were used:

Tromso Social Intelligence Scale (Silvera, Martinussen, & Dahl, 2001) consists of 21 self-evaluation items (in our case 7 items) to which the respondents respond on a 7-point scale of the agreement degree (1-describes me very poorly, 7-describes me very well). The questionnaire is divided into 3 subscales, which enable specification of 3 factors: social information processing, social skills, and social awareness. In this study, we used only the self-awareness (7 items) skills assigned part of the questionnaire. The internal validity of these factors is given as follows: social information processing - .79, social skills - .85 and social awareness - .72 (Silvera, Martinussen, & Dahl, 2001).

The Problem Solving Inventory (PSI) (Heppner & Petersen, 1982) is a 35-item instrument (3 filler items) that measures the individual's perceptions regarding one's problem-solving abilities and problem-solving style in the everyday life. All items are scored on a six-point Likert scale, ranging from 1 = Strongly Agree to 6 = Strongly Disagree. A total score can be calculated as a general index of problem-solving appraisal that ranges from 32 to 192. Lower scores on each factor and on the total PSI score are considered more functional. The reliability coefficiency (cronbach-alpha) of the problem solving inventory was found as .90. (Heppner, Witty, & Dixon, 2004).

Jusupov's questionnaire of empathy level diagnostics to determine empathy types (Столяров, 1990). The questionnaire consists of six empathy scales, which express relationships with parents, old people, children, characters of pieces of art, strangers, and animals. The questionnaire comprises 36 items, the person has to evaluate each of them and mark if he agrees or disagrees with the statements, one of six answer variants is chosen: 0 = don't know, 1 = never or no, 2 = sometimes, 3 = often, 4 = almost always, 5 = always or yes. The Lithuanian version of the Jusupov's questionnaire of empathy level diagnostics has a reported internal consistence of .64 (Akelaitis, 2015).

The General Trust Scale (Siegrist et al., 2003) is a 10-item self-report instrument that measures general trust defined as „the conviction that most people can be trusted most of the time". The internal consistency of the General Trust Scale is strong (cronbach-alpha =. 87) (Siegrist et al., 2003).

Educational experiment was used as a method to verify the efficiency of the educational programme. The essence of the educational experiment was the social skills enhancing programme for senior high school age students in physical education classes.

Statistical Analysis. The data were analysed by applying SPSS 19.0 (*Statistical Package for Social Sciences*). Descriptive statistics, means (M) and standard deviation (SD) were calculated for each of the items of the tests. Cronbach's alpha coefficients for internal consistency of the scales were calculated. A preliminary analysis used the Student *t* test for independent samples, comparing the experimental group with the control group with the aim of checking whether the two groups were homogeneous. Then, considering the recommendation of Arnau and Bond (2008), repeated measures (RM) multivariate analysis of variance (2 × 2 (Group × Time) MANOVA) was used in order to analyse the effects of the educational program. Wilks's lambda was used to evaluate all multivariate effects; the significance level was set at .05. Effect sizes for F-statistics were expressed as partial eta-squared (η_p^2). According to Tabachnick and Fidell (2007) effect size based on $\eta_p^2 = .01$ corresponds to a small effect, $\eta_p^2 = .09$ corresponds to a medium effect, and $\eta_p^2 = .25$ represents a large effect.

Sample and procedure. The educational experiment was applied during the period from November 1, 2015 to April 30, 2016. The educational experiment employed a random serial (probability) sampling method. Two 9th grade classes from the same secondary school of Kaunas district were randomly selected and assigned to the experimental and control groups. The experimental group consisted of 25 students and in the control group there were 26 students (overall 51 subjects). There were no significant differences between the experimental and the control groups by age (t (49) = -.60; $p > .05$) and gender (χ^2 (1) = .02; $p > .05$).

The educational experiment aimed at evaluating the social skills of senior high school age students in physical education classes before the educational programme and after it. The experimental group students participated in educational program of social skills that included twenty- eight 15 minutes long (total: 7 hours), structural physical education classes. For the each component of social skills to develop, we used the same number of training sessions (7 sessions). Education influence on control group was not applied.

To develop senior high school age students' social skills in physical education classes we used these stages of education: 1) *description of a skill*; 2) *demonstration*; 3) *practice*; 4) *feedback*; 5) *reinforcement of educated skill*.

The several methods of education were applied to develop senior high school age students' social skills in physical education classes: *modelling positive behaviour*, *role plays*, *small groups*, *agility games*, and *group discussions*.

Results

Student's t test for independed samples showed that according to the components of social skills, the experimental and the control group before the experiment did not differ significantly: social awareness (t (49) = -.20; $p = .85$), problem solving (t (49) = -.51; $p = .61$), empathy (t (49) = .04; $p = .97$), and trust in others (t (49) = .34; $p = .73$).

Overall RM MANOVA results showed significant effect of the educational programme on the components of social skills among senior high school age students in physical education classes, i.e. the influence of group by time interaction was significant (Wilks Lambda = .73; F (4,46) = 4.34; p = .005; partial η_p^2 = .27). Univariate tests of RM MANOVA revealed the significant effects of an education programme on these components of social skills: social awareness ($p < .01$), empathy ($p < .05$), problem solving ($p < .05$), and trust in others ($p < .01$). The results are summarised in Table 1.

*Table 1. The statistical indicators of social skills among senior high school age students in physical education classes before and after the educational experiment (M ± SD)**

Social skills	Experimental group		Control group		Univariate tests of RM MANOVA Group × Time		
	Before experiment	After experiment	Before experiment	After experiment	F	p	η_p^2
Social awareness	25.48 ± 7.01	35.32 ± 8.15	25.88 ± 7.75	26.96 ± 5.16	13,45	.001	.22
Empathy	75.08 ± 29.00	101.80 ±43.94	74.81 ± 21.89	76.50 ± 10.74	6,63	.013	.12
Problem solving	126.32 ±12.92	102.76 ±35.16	123.96 ±19.17	117.73 ±12.87	4,63	.036	.09
Trust in others	28.56 ± 2.95	33.28 ± 8.69	28.23 ± 3.85	27.27 ± 3.37	9,09	.004	.16

Notes. ($M \pm SD$) – mean and standard deviation; (η_p^2) – effect size.

Discussion

In the current study was found that after the end of the educational experiment experimental group students demonstrated better social awareness (a medium effect, η_p^2 = .22), empathy (a medium effect, η_p^2 = .12), problem solving (a medium effect, η_p^2 = .09), and trust in others (a medium effect, η_p^2 = .16) skills in physical education classes. The findings of the educational experiment confirmed our research hypothesis that the application of education programme would allow expecting more developed social skills among senior high school age students in physical education classes. This finding was similar to the findings of Ang and Hughes (2002), Alwell and Cobb (2009), Durlak, Weissberg, & Pachan (2010), Durlak and colleagues (2011) whose investigated the effectiveness of social skills interventions (effect sizes ranged from medium (η_p^2 = .09) to large (η_p^2 = .26)).

Various reviews of studies have found consistent evidence on the positive impact of school-based social emotional education programmes on students of diverse backgrounds and cultures from preschool to secondary school in social and emotional health (Zins et al., 2004; Payton et al., 2008; Durlak et al., 2011; Sklad et al., 2012). The largest average effect sizes appear to be in social and emotional skills education, but the programs also enhanced academic achievement and reduced internalized and externalised conditions, such as anxiety, depression, substance use and aggressive and antisocial behavior (Payton et al., 2008; Durlak et al., 2011; Sklad et al., 2012). Weare & Gray (2003) reported a wide range of academic, social and emotional benefits, such as improved positive behavior, better learning and academic progress, improved social cohesion and inclusion and better mental health. Meta-analytical review of 75 experimental or quasi-experimental studies on the effectiveness of universal school-based social emotional education programs in the USA and other parts of the world, including Europe, Sklad and colleagues (2012) reported the overall impact on all the seven outcomes measured, namely, enhanced social skills, positive self-image, academic achievement, mental health, prosocial behavior, reduced antisocial behavior and substance abuse.

Study limitations. Limitations of the study is that it analyses only senior high school age students' peculiarities of the education of social skills in physical education classes, although further study is worth to analyse middle or primary school age students' peculiarities of the education of social skills in physical education classes as well and compare data of these age groups students.

Conclusion

Educational experiment showed the effect of social skills education programme among senior high school age students in physical education classes for the senior high school age students' social skills education (learning) in physical education classes: the social skills education programme applied during the educational experiment had a statistically significant effect on the components of the experimental group senior high school age students' social awareness ($p < .01$), empathy ($p < .05$), problem solving ($p < .05$), and trust in others ($p < .01$) skills in physical education classes.

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CROATIAN BASKETBALL IN CONTEMPORARY SOCIETY – WHERE HAS NATIONAL IDENTITY DISAPPEARED?

Bartoluci Sunčica, Ukić Marita
Faculty of Kinesiology, University of Zagreb, Croatia

Abstract

Sports sociologists claim that general societal changes are also deeply connected with the world of sport. This claim can also be applied in the field of Croatian basketball. States that have undergone significant socio-political changes, such as Croatia, are fertile ground for research of national identity and its connection with sports. This article will deal with what has changed in Croatian sport and society since Croatian basketball's greatest success – a silver medal at the Olympic games in Barcelona – with an accent on the significance of national identity.

Through a qualitative discourse and content analysis of Croatian daily newspapers (Sportske novosti, Jutarnji list, Večernji list), we shall attempt to explain how two large sporting events (the 1992 Olympic Games and the Euro Basket 2017) in which the Croatian national basketball team competed affected the structure of national identity in different ways. Taking into account the period of 25 years that marked the transition from a post-socialist society into a "crony capitalist" society, we suppose that changes have also taken place regarding the perception of the role of sport in creating national identity. Players in the 1990s who refused to play for the national team would be labeled traitors to the nation. We examine what is happening a quarter of a century later – do refusal to play for the national team, victory, and defeat carry the same weight? How connected is the relationship between basketball and Croatian society with media constructions versus real events in society as a whole? Based on a discourse analysis and a qualitative content analysis, we shall examine this case on three levels: media discourse, political discourse, and the discourse of the key players themselves – top athletes.

Key words: *national identity, basketball, content analysis.*

Introduction

Acknowledging sport and its place in society is of great importance if we want to fully understand society and culture. Many authors are describing sport as a reflection of society (Jarvie, 2013; Perasović & Bartoluci, 2007). That is why it is important to focus on understanding the deeper meaning of sport in society. Sport can be studied in many different sociological contexts, but this paper is dealing with the connection of national identity and sport. This relationship is a highly relevant social issue, and systematic sociological analysis is needed to understand it. The role of sport in the making of nations is one of the most discussed areas in sport and culture (Jarvie, 2013), and it also increases the political meaning of sport. The concept of national identity is of exceptional importance in the field of sport, and its greatest expression can be found during national team play. Countries with short histories of nationhood often resort to sport to (re)inventnational identity (Ličen, 2011). They also often use sport to promote themselves, to emphasize their superiority, as well as to strengthen the national spirit, and the winning of awards thus becomes a sign of power and superiority (Coakley, 2009).

All of the above can be clearly observed in the Croatian national basketball team. As a country that only 25 years ago gained independence and international recognition, Croatia went through many changes, which are noticeable in the sport field as well. Sport has always been an arena in which various social actors and groups can actively rework their relationships and respond to changing conditions. Since the founding of Croatia as an independent nation-state in the early 1990s, sport and politics in the Croatian socio-political context have been intertwined. Politics is most involved in sport during and after the war. Then, sport turns into the battle of teams and individuals who symbolise their nation (Bartoluci, 2013). After political and sociological changes that happened when Croatia gained independence as a new nation-state, the country tried to form a position on the European and world scene. Players and their success were used for that purpose.

Basketball has an important role in a broader social context. Croatian basketball team that played in the Olympic games in Barcelona in 1992 inherited Yugoslavian basketball team, which participated in many large sporting events and won numerous medals. Basketball, as one of the most popular sports in Croatia, has a long and successful tradition. It was internationally known for its players and the famous "Yugoslavian basketball school". In the nineties, every medal except the golden one was considered a failure. Still, Croatia won the silver medal "with a golden shine" in 1992 Olympic games, when it lost in the finals against the "Dream Team", USA. That medal was perceived as much more than a sporting success in the eyes of the Croatian public. It was considered a success of the entire state. This event contributed to the international promotion of Croatia as the new nation-state. To date, the last medal won by the Croatian team was the bronze one at the European Championship in Athens in 1995. In the same championship, Yugoslavian basketball team (then consisted of Serbia and Montenegro) won the gold medal. Croatian basketball players left the ceremony during the Yugoslavian anthem, and there is still a prevailing theory that this act "had sealed the fate" of Croatian basketball at major events by "putting a curse" on it because of the unprofessional character of the act. Although we still have talented basketball players who have outstanding careers in their clubs, for many years now, something has not been right in the Croatian national basketball team. It is difficult to find a precise cause of this, but the social and political context must be taken into account when discussing this topic. As a country, but also as a "sports nation", Croatia went through socio-political transformation. We cannot compare the importance of playing for the national team in the nineties, during and shortly after the war, when sporting success meant national success. Today, twenty years later, the context has changed, and so has the understanding of the importance of playing for a national team, for both players and the public.

Apart from the social and political changes that have taken place, the media play a substantial role in shaping opinions on many issues, and national identity is no exception. The media have come to play a fundamental role in the consumption, ownership and delivery of sport (Jarvie, 2013).Sports media have a strong influence on the perception of the public, as well as the players themselves, about the importance of playing for the national team. The media shape a viewer's identity in terms of both individual and group components of a person's self- perception. Many media scholars and professionals refuse to acknowledge sports as a "serious field"; however, it is very influential in that it reaches a much broader audience than a lot of other media content. Viewers' perceptions of individual characteristics such as gender, ethnicity and nationality are shaped by television's selection, narration and description of events.

Taken all of the above into account, the aim of this paper is to explain how two large sporting events (the 1992 Olympic Games and the Euro Basket 2017) in which the Croatian national basketball team competed affected the structure of national identity in different ways, using a qualitative discourse and content analysis of sports media.

Methods

A qualitative case study was carried out. In the first phase, we analysed the literature in the field of sports sociology. Two cases were analysed – the 1992 Olympic Games in Barcelona and Euro Basket 2017 in Istanbul. Discourse and content analysis of media statements made before, during and after particular sporting events was performed. All articles concerning key sporting events published in daily newspapers three days before, during, and three days after the events were also analysed (*Večernji list, Jutarnji list,* and *Sportske Novosti*). Game coverage on national television was also analysed, as well as the websites (*index.hr, jutarnji.hr, telegram.hr*). Based on the discourse analysis and qualitative content analysis, we will examine this case on three levels: media discourse, political discourse, and the discourse of the key basketball players themselves.

Results and discussion

It is not surprising that the matches in 1990s were a reflection of political tensions and ethnic conflicts during that period. Stressing that this sporting event is under "Croatian slogan", "played in shirts with Croatian coat-of-arms", that "Croatian dream come true" – the newspaper reports apostrophize the national importance of participation in the Olympic Games for Croatia as an independent state, which is particularly visible in the texts that follow the last matches of the Olympic tournament (Bartoluci, 2013)."*The Olympics in Barcelona have never been just a sporting event, everything made sense, the new country...Everyone agreed that this Olympics would be more than the Olympics for us Croatians…"* (17,40).

In 2017, we can see that the players are emphasizing the importance of the game, power and winning. Today's players mostly play because they want to compete. "*We go to the European Championship to play a sport that requires certain skills, and if we are not at an enviable physical level, we can have all the chemistry we want and fight as much as we want, but no one will recognize it or achieve the result… I like to play for the national team, I like basketball, I love to compete. There will be time for rest when I stop playing".* The following statement is of great importance when researching how players perceive national identity nowadays. "*I do not want to deprecate anyone. I don't think I'm a bigger Croat, nor I'm a better man than someone else just because I'm playing for the national team. Simply put, I have some different views than others, different motives* (Čobanov, 2017). However, even though the war ended a while ago, and socio-political context has changed dramatically, as well as the way the public perceives the players, one of the best Croatian players, 23-year-old Dario Šarić, perceives his role in the Croatian national team differently. During the Euro Basket, he stated that he would immediately exchange his *"NBA Rookie of the Year Award"*, if he got one, for the Croatian medal on this championship, and that his role in the team was more serious now when it was his responsibility to take his team to victory. The example of Dario Šarić is an exception to today's understanding of the national identity because of the circumstances in which he grew up. He was born and brought up in Šibenik, a city heavily affected by the war, where he socialized in a multiethnic environment. Dražen Petrović was his role model in both sporting and human sense. Petrović was very active in the attempts of political affirmation of a newly formed nation-state in 1990s, he was one of the first basketball players who refused to appear on the Yugoslavian team. Dražen's sports achievements, personal engagement during the war and a special sport spirit created an image of him as a great sports icon in the Croatian society.

A quite extreme case of mediated sports nationalism occurred on the national Croatian radio-television in 2007. Before the Euro Basket 2017, Šarićhad shared a video clip of this case on his official Facebook page. This occurred 15 years after Croatia gained independence. After reporting that four basketball players had declared themselves unavailable for a then-upcoming national team training camp, then present sports editor labeled the act a "sporting betrayal" and addressed the players with the following words: "*Gentlemen basketball players, the flag is sacred and the national anthem is life. Not so few of your peers did not reach your age because they lost their lives so you could play for Croatia; for Croatia you do not wish to play"* (HTV, 2007). This case shows how sensitive the Croatian public about the question of playing for the national team. By posting this video clip, Šarić showed indirectly that he also condemned the cancellation of the national team play in the same way. From his example, we can conclude how national identity is not just a question of time and space, but also of social circumstances. The case of three young players, who were unavailable for the national team in 2017, is very significant. All of them stated that the Croatian basketball team is of great importance for them, and then cancelled at the last moment. At Euro Basket 2017, the Croatian team, that should have been "rejuvenated", was supposed to be led by these players, so their dismissal was not appealing to the public. Still, the reporter from the Euro Basket 2017, on that same television said: "*There is no Hezonja, Zubac and Žižić, but it needs to be respected and we need to focus on those who are there*". From these statements, we can clearly distinguish the perception of playing for the national team. While only ten years ago such an act was described as "treacherous", today, respecting the players' decisions is highlighted. In a way, we notice national identity manipulation. Although it is a personal matter of every human being, it is publicly changing under the influence of circumstances.

It is interesting how the basketball players who competed in 1992 are now important members of the team, but in a different role. They are members of the Croatian Basketball Federation, which many people blame for the situation in Croatian basketball today. As we have already stated, sport is a kind of mirror of society, and for this reason we see how the bad situation in the state is reflected in sports. *"My impression is that everything is not done properly. There is no real cohesion within a complete organization, I mean the Federation. And because there is no unity of spirit, we do not have the right to be optimistic. It certainly is a handicap. And the fact* *that Žižić, Hezonja and Zubac cancelled the game for the national team is a particular question. It is no coincidence that three of them are run by the same manager. In basketball, there are many conflicts of interests in which relations between coaches and managers are intertwined. And FIBA has failed to resolve that. But the issue of FIBA's role, in fact the importance of this once powerful organization, is for another discussion. The fact is that FIBA had completely lost its power"* (Reić, 2017).

One of the former players sees things differently. To him, playing for the national team should be a matter of honour and pride. We quote the statement: *"I really do not see any sense in giving a paper to an American to become a Croat overnight. Then my mother could also lead the team. Others do it if they want, we will play with whom we have"* (Čobanov, 2017).

In 1992, in the public discourse, the emphasis of an ethnic origin of an individual became more respected as a generally accepted practice. This is also apparent from an analysis of the discourse of the interviewees, who sometimes "unconsciously" emphasize their ethnic origin.

"*In the '90s you could not say you did not want to play for the team. In fact, this concept is unclear to me today. I can understand somebody for certain reasons, but if you are healthy, I just think that's the question, whether you want to play for the team or not. Everything else is unclear to me. "(11, 28)*. Giving a special status to an athlete, in terms of understanding athletes as people of national significance, is an indicator of ethnic nationalism. An interviewee says that if a man appears on a national team, in any sport, especially at the Olympics, it means that he has done something for the state (17, 6), so in that sense he has a special significance for the nation-state. This generation of basketball players enjoyed a great national reputation, and that is reflected in a number of different examples. One of the clear indicators is the fact that after the medal at the Olympic Games in Barcelona they received diplomatic passports.

Conclusion

An analysis of the events relating to the Croatian national basketball team shows how significant sport is in the creation of national identity, and it allows an understanding of the time and context during which Croatia was being created as an independent state. The most promoted social group is the nation; patriotic flag waving pervades sports broadcasts, and an inclusive discourse contributes to framing the audience as an active part of "national successes." The reasoning behind it is that this is what viewers want. That is why it is particularly important to study media narratives related to big sporting events.

The result of the research shows that through the analysis of a sports case we can get a clear picture of a social and political situation. In the social sense, Croatia experienced numerous transformations that also manifested in the field of sport. Today, a quarter of a century later, the context has changed, which has also resulted in a change in the significance of playing at the national level. Media discourse surrounding the events of the 1990s emphasized sporting goals as well as national successes. The attitude towards the ethnic "other", in which "we" are the epitome of positivity, while "they" are the epitome of negativity, is a clear indicator of the ethnic form of nationalism, which prevailed over the civic form of nationalism back then. In 2017, during broadcasts, the commentators report exclusively on the player's performance and the game itself. Twenty-five years ago, statements about the importance of presenting the country, and about the significance of playing for the players themselves, were most commonly encountered in the media. Today, with regard to the socio-political circumstances, fewer such statements are expected, but some of the players emphasize the importance of playing for Croatia, regardless of any possible problems. Therefore, a possible conclusion is that the public narratives in Croatia serve as a framework for understanding the broader political situation in the country and indicate changes of social circumstances.

National identity and sport are deeply connected in Croatian society. A quarter of a century after the Olympic medal in Barcelona, the socio-political conditions that manifest in the field of sport are fundamentally different. The war ended long ago, social relations in the region are normalized, but the transition from socialism to the so called "wild capitalism" did not happen without consequences for the society as a whole. All the changes in a neoliberal society were reflected in Croatian basketball. Twenty-five years after the first great success on the international scene, the desire for success and reaffirmation of national identity has not disappeared, but because of wider social changes it has changed the its focus.

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MEDICAL AND BEHAVIOURAL CHARACTERISTICS OF THE SECONDARY SCHOOL TEACHERS OF PHYSICAL EDUCATION

Kotlík Kamil, Jansa Petr
Faculty of Physical Education and Sport, Charles University in Prague

Abstract

In paper we mention chosen secondary school teachers (with PE teaching qualification) opinions and attitudes to a daymode and regimen. Further, we focus on a psychosocial function of motion activities and sport. This paper is a part of a wider research and follows the part dedicated to teachers with other qualifications.

The research survey was implement by a method of questionnaire in different types of secondary school (grammar school and vocational school with GCSE exam). The total number of repondents was 461 individuals (262 men and 199 women). For the purpose of a graphical and statistical data processing SPSS and Excel programmes were used. The results we present from the viewpoint of gender.

We consider as a positive findings that a big majority of teachers supports adequate motion activities and sport. The negative finding is mainly the fact that the majority of research sample get stressed because of their work very often.

Key words: *teacher, secondary school, daily regime, regimen, physical education, sport*

Introduction

Programmes of physical education at secondary schools represent the specific educational area, which places extraordinary and special demands on the teachers of this subject. A quality teacher of physical education should have some specific knowledge, abilities and skills. Physical education belongs to so called practical subjects, which are influenced also by own experience and sporting past, especially by the experience of the previously practiced sport (Jansa, Kovář, & Dřevikovská, 2012).

Foreign research on health and behavioural characteristics is conducted by, for example, Alan, Chan, Chen and Chiny (2010), Armour (2011), but in particular by Miskel, Hirvensalo and Whipp (2015), who point out that a number of physical education teachers are leaving the profession because of work-related stress and dissatisfaction with the activity being performed. The purpose of their investigation was to determine the seven factors of satisfaction. They watched those PE teachers who were happy with the resources, the working community, managed the students, and wanted to stay in the profession. The topic is investigated also by Czech authors, e.g. Lazarová and Jůva (2010), Válková (2011), Jansa, Kovář and Dřevikovská (2012), Jansa and Kotlík (2014) and others.

Very interesting results are presented by Schuster, Krejčí and Pešek (2014) as part of the international project EU INTEREG IV- 16 PACZion (2008 - 2012), which is an international union between Pasov and České Budějovice, supporting the health of teachers. The examined group consisted of 25 male and 22 female teachers aged 41 to 60, represented by teachers from all school levels, ranging from maternity to high school, including teachers of physical education. The project was focused on intervention in health promotion - calming and relaxation techniques or adequate physical activity (especially hiking, yoga exercises, Nordic walking, cycling, fitness swimming, aerobic exercise, adventure outdoor activities, etc.). During the reporting period, the average weight of 25 teachers dropped from 74.9 kg to 74.6 kg. The average percentage of fat content decreased from the initial 35.5 % to 29.1 % and the average amount of fat from 27.1 kg to 22.3 kg. The results can be assessed as very positive, not because of a slight decrease in weight, but mainly due to the sharp drop in fat.

Methodology

Goals and hypothesis

Our research was focused on gaining opinions and attitudes of PE teachers at secondary schools to daily program and regime, including psychosocial functions, physical education, physical activity and sport as part of their lifestyle.

Partial task of the work is to make an elementary description among the groups of PE teachers at secondary schools by gender, in terms of the orientation of their opinions and attitudes in selected issues,

We formulate the working hypothesis in such a way that the results obtained may say that PE teachers at secondary schools have different attitudes to these issues by gender. In spite of possible negative results, we still assume that PE teachers will have significantly more positive results in the most of the observed modecharacteristics in comparison with the total population of the Czech Republic.

The Research Tool

To retrieve data, we used The “Questionnaire for Pedagogues” (Kalíšková, 2010), which has following structure:

- the first part included questions about opinions and attitudes towards physical activities and sport in general contexts (6 items),
- the second part was dedicated to observing the daily regime and living (8 items),

- the third part included data on regular sports and physical education activities (8 items),
- the fourth part was focused on identification data (7 items.).

For the purposes of this study, we used the first part of the questionnaire, which deals mainly with the daily regime and the living of physical education teachers at secondary school.

The Organization of the Research

In total, 461 questionnaires were obtained from secondary school teachers with the PE approval. The two-stage stratified selection was carried out in the Czech regions, including the city of Prague. The questioning was done anonymously. The results are analysed in terms of gender within the statistical programs Excel and SPSS.

The Group Characteristics

In our investigation, there are more men (262 persons, i.e. 65.5 %), than women (199 persons, i.e. 34.5 %). We are aware of the fact that this may be one of the limits of the study, because according to the available data from the Czech Statistical Office, 35 % of men and 65 % of women work at secondary schools (http://www.statistikaamy.cz/2016/03/oproti-zahranici-u-nas-uci-mene-muzu/, 2016). Our investigation only applies to the teachers who have received physical education approval, usually in combination with another, usually educational subject.

Results and Discussion

Daily regime, or its structure, is integrally based on the value system of an individual.

Into this daily mode, we include such activities that are currently or from a long-term point of view at the forefront of our value system. Essentially, it does not matter whether it is an activity felt as a possibility of subjective choice (hobbies, sleeping, eating and living, etc.) or as an obligation coming from outside (obligations arising from employment, stable social roles, etc.). On the contrary, activities that are at the bottom of the individual's value system are included rarely, reluctantly or never, despite their possible objective utility that the individual is aware of. This refers, for example, to the necessary time of sleep, regular physical activity, healthy eating etc., i.e. those activities whose benefits are generally known, but most people do not respect them for various reasons.

Firstly, we are focused on the regularity of the daily regime of PE teachers. Due to their education and profession, which they have freely chosen, their daily regime should be rather regular and we should not find significant differences between the sexes. Of course, the day mode has many variants that would be very difficult to grasp. To make it easy, we decided to characterise the daily regime by three basic components, namely sleep, work and rest (or time available for non-work activities). The results on the regularity of the daily regime of PE teachers at secondary schools are displayed in Graph 1.

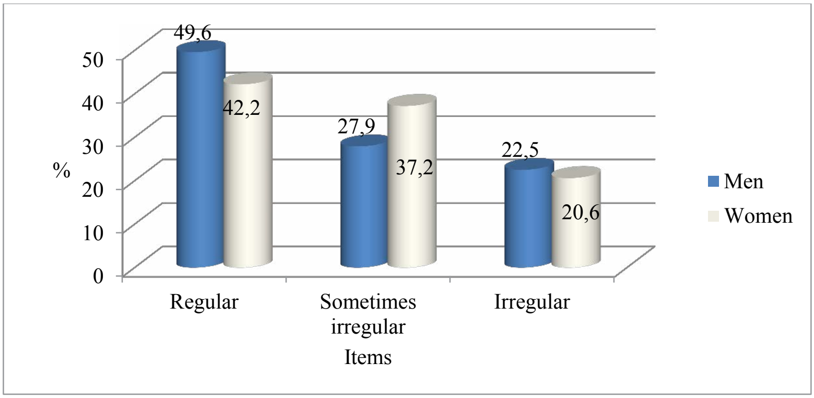

Figure 1. What was your daily regime within the last 6 months (sleep, work, rest)?

Interesting is the fact that male PE teachers have a regular daily regime of 7% more than women. This result does not correspond to the general consciousness that most female PE teachers tend to have a more regular daily regime. The observed result deserves to be verified in a further research survey. Even more significant is the fact that while 49.6 % of the interviewed PE teachers show a regular daily regime, the same is true for only 33.6 % of their colleagues without approved physical education.

Another important and integral part of the daily regime is the diet. While, for example, sleeping time or its quality cannot always be completely influenced, the regularity of eating (especially in the teaching profession) can. This issue is dealt with in Graph 2.

It can be seen from Graph 2 that in more than three quarters of cases, physical education teachers eat mostly regularly (79 % of the men and 77.4 % of the women voted for the answer “yes” or “often”). The most striking difference between men and women is in the “yes” category, in the case of regular meals. An important finding is the fact that there are about 18 % more PE teachers who eat regularly than their colleagues with other approvals. This fully corresponds to the findings presented above in the text devoted to the regularity of the daily regime. Except for the first mentioned, the differences between male and female PE teachers are meaningless and statistically insignificant.

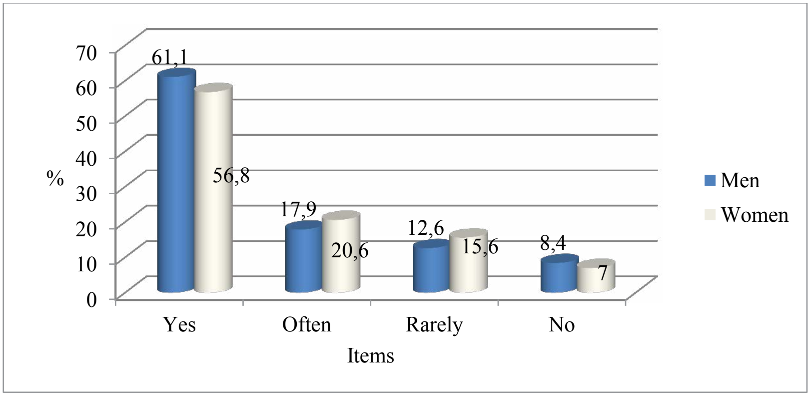

Figure 2. Dou you take your meals regularly (breakfast, lunch, dinner)?

Naturally, our study is limited by the fact that we have not focused on the usual composition of the diet, or the time space for individual meals, or their usual daily time. This already exceeds the possibilities of this research and is an opportunity for further investigation. The next part of the questionnaire was devoted to the regularity of sleep (but it did not examine its usual length, the normal time in which it is realized, or its subjective sufficiency). Below are the facts presented in Graph 3.

In the case of regularity of sleep, we find a statistically significant difference between males and females teaching physical education at secondary schools only in the "often" category, but it cannot be interpreted as a serious finding. If the category "often" merges with the extreme category "Yes", then the differences between men and women are almost equal.

The main result is that male and female PE teachers at secondary schools try to have regular sleep in about three quarters of cases and are therefore fully aware of its many-sided importance. Within the interrogated group, the results on the regularity of sleep are closely related to the regularity of eating, which we consider to be a valuable and important finding.

Comparison of the regularity of the sleep of physical education teachers at secondary schools with the majority population of the Czech Republic is a relatively difficult matter since most of the investigations do not deal with the regularity of sleep but rather with its duration or quality (e.g. various investigations by ppm factum research, s. r. o.).

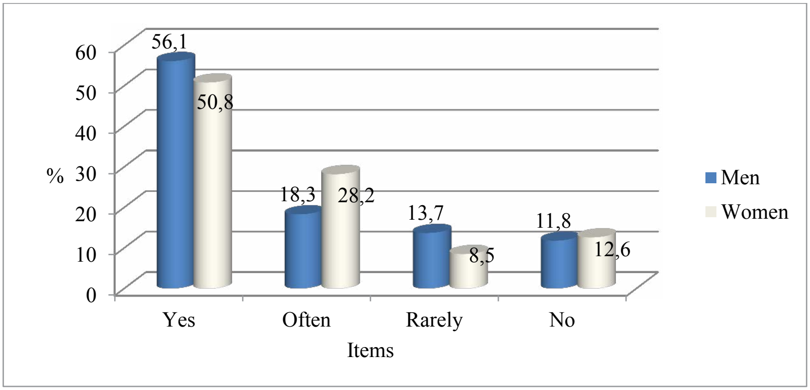

Figure 3. Do you have your sleep regular?

The usual finding is that the average sleeping time of the Czech Republic's population is constantly decreasing, and currently it is about 7 hours 15 minutes. This trend corresponds to the situation both in the European Union and in North America (http://www.factum.cz/aktuality/aktualita/spanek-je-pro-regeneraci-klicovy-jak-spi-cesi, 2014).

A very important factor that affects the individual's health and, indirectly, the daily regime is the stress, namely the stress situations, in which one gets. The subject of our survey was, due to the focus of the research on the professional group of physical education teachers at secondary schools, stress resulting from the profession of the PE teacher. So we were wondering how often the interrogated individuals got into stressful situations arising from their work environment. The frequency of working stress on physical education teachers at secondary schools is illustrated in Graph 4.

According to the European Agency for Safety and Health at Work, more than two thirds of the population in the Czech Republic are exposed to disproportionate workload and these workers are thus at risk of work-related stress

(https://osha.europa.eu/cs/surveys-and-statistics-osh/european-opinion-polls-safety-and-health-work/european-opinion-poll-occupational-safety-and-health-2013, 2013). In view of the above, the results we have found can be evaluated as positive, as 22.9 % of male and 21.1 % of female respondents suffer from stress every day.

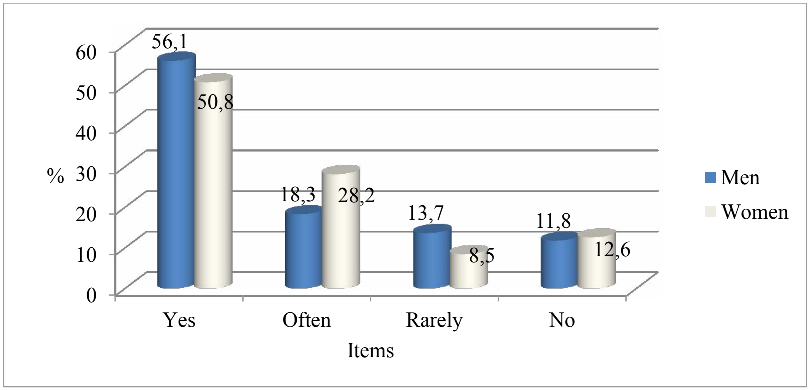

Figure 4. How often do you get into the stressful situations because of your job?

An interesting and important finding is the fact that 39.5 % of male and 35.2 % of female respondents feel no work stress at all. If we compare male and female secondary school teachers of PE, we come to conclusion that women experience a higher level of stress as a result of their workload and working environment, by about 9 % (see above).

Conclusion

The professional group of the secondary school teachers, who have been interviewed by us, adheres to a high, generally healthier lifestyle than is common with the majority of the Czech population; nevertheless, there are couple of negative facts. These include, for example, the differences between men and women in work-related stress.

On the other hand, the positive facts are the overall results related to the regularity of the daily regime, sleep, eating and, to some extent, stress. It is also clear that sport and physical activity have a stable position in the value system of physical education teachers at secondary schools and that their choice of profession corresponds to their life beliefs.

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The postal addres of the first author:
PhDr. Kamil Kotlík, Ph.D.
Department of Pedagogy, Psychology and Sport Didactics of FTVS UK
José Martího 31, 162 52 Praha 6 – Veleslavín
E-mail: kotlik@ftvs.cuni.cz

PARENT–ATHLETE INTERPERSONAL RELATIONSHIP IN SPORT: THE IMPORTANCE OF ATTACHMENT

Lisinskiene Ausra
Lithuanian university of educational sciences, Vilnius, Lithuania

Abstract

The purpose of this qualitative interpretative phenomenological analysis was to examine parent–athlete interpersonal relationships in youth sport. The second aim was to gain an understanding about the importance of the athlete attachment to parents in youth sport. Interpretative Phenomenological Analysis method (IPA) (Smith, Larkin, Flowers, 2009) was selected. Eight youth sport parents participated in one in depth semi–structured interview (total of eight interviews). The data were analyzed using interpretative phenomenological analysis. Three key themes were identified: Parent–athlete attachment; Secure athlete attachment to parents; Insecure athlete attachment to parents. The phenomenological interpretative analysis has revealed the importance of athlete attachment to parents in youth sport. Interviews with athlete parents revealed that involvement into children's sport is more important in the early period of youth sporting experience and become less appreciable or unwelcome when children gain sporting experience. Parents–child attachment in early childhood has an affect in youth sport participation. Secure attachment ensures a positive and safe development in children's sports: the child becomes confident, independent, goal–seeking, result oriented, able to regulate emotions in sport and easily integrates into a sporting environment. In contrast, insecure parent–child attachment leads to an athlete demotivation, disability to survive in a competitive environment which in turn can lead to a drop out of sport phenomenon.

Key words: *Parent, athlete, attachment, sport.*

Introduction

A phenomenon of parent–child attachment is of the highest importance (Bowlby, 1969; Prior &Glaser, 2006; Carr, 2014; Sukys, Lisinskiene, & Tilindiene, 2015; Lisinskiene, 2016). Attachment theory states that the psychological and behavioral effects of early parent–child relationship will affect the development of close relationships with other people in the future (Bowlby 1969; Ainsworth 1989). The basis for the development of attachment in children is the need for security that can be provided by an adult persons (Prior, &Glaser, 2006). One of the important tenets of attachment theory is the notion that early childhood lays the foundations for the development of personality through the lifespan (Bowlby, 1969). J. Bowlby (1973) reflected this assumption and he believed that infants are biologically predisposed to form selective bonds with special and proximate caring figures in their environment, proposing that experiences in relation to such bonds are a critical factor in the development of internal working models of the world. The aspect of attachment becomes of prime importance in the lives of adolescents who are passing through a period of psychological and social transition between childhood and adulthood (Nawaz, 2011). The family's influence begins with early childhood interactions and continues through adolescence age and young adulthood (Sudani, & Budzynska, 2014).

Attachment is the quality of the attachment relationship which a child or other individual is able to form and can be grouped as either secure or insecure. Infants are usually distressed by separation. On reunion they greet parent, receive comfort if required and can return to play. In adolescence and adulthood, secure attachment (indicated by low scores on anxious and avoidant attachment) is associated with healthy expression of emotions, easy and accurate access to memories of emotional experiences, appropriate self–disclosure, confident, empathetic, and goal seeking, uses effective problem–solving strategies. The other three attachment patterns are forms of insecurity and are associated with later behavioral problems, poorer mental health, and, in some cases, delinquency, criminal behavior, and incarceration (Shaver, Mikulincer, & Feeney,2009). As family is the most sensitive environment where the personality of adolescents is formed (Steinberg, 2014), parental mission is to guide the child into activities that, through continuous participation, would build the child's self–confidence and ability to solve problems, teach aim setting and instil values (Warner, Dixon, & Leierer,2015). Deliberate practice and its advantages have been widely researched (Lisinskiene, 2016; Strachan, Côté, & Deakin, 2011; Vierimaa et al., 2012). Participation in sports is one of social activities that has a positive effect on a child's development. This attractive activity with respectable image can lead to positive social changes. Participation in sporting activities gives children the opportunity to enjoy high–quality leisure time; children become more disciplined and active in many different spheres (Rottensteiner et al., 2013). Carr's (2014) investigation was an important first step towards understanding the manner in which adolescents' internal working models of attachment relate to their friendship quality in the context of youth sport. Secure and insecure parent–child attachment transforms into a sport context. The quality of interpersonal relationships between the parent and the child strongly depends on the quality of interpersonal relationships created in early childhood. Affectionate relations between parents and children influence the formation of close links with other people (Lisinskiene, 2016;

Steinberg, 2014). The importance of attachment becomes apparent in adolescence – the period of psychological and social transition from childhood to adulthood (Nawaz, 2011). Early parent–child relationship plays a vital role in this period. Attachment and relationship with parents change in the period of adolescence, young people becoming more independent from their parents. In this period the parent–child attachment weakens as young people are faced with new challenges; they seek independence and self–sufficiency, develop their self–identity. In sport athletes are more likely to build relationships with coaches and each other, based on their attachment styles with parental caregivers. In adolescence, teenagers positive experiences enable them to develop a secure attachment style which helps to build a positive, internal perception of themselves and facilitates positive relationships in sport. In addition, the way young people build relations with other teammates or coaches reflects the bond which they share with their parents (Dawood Al Sudani, Budzynska, 2014). The quality of athlete attachment to parents have an impact on athlete motivation on sport performance. According to Dawood Al Sudani, Budzynska, (2014) it is important for athlete to have in early childhood a positive bond with parents or caregivers, to grow up in a family where there is a mastery climate and there is personal development of motor skills and abilities and to have parents who believe in your competence and support your motivation for involvement in sport.

The findings of scientific studies on family involvement into adolescents' activities are significant in terms of importance of attachment to parents in the period of adolescence. However, qualitative research into children's attachment to parents in the context of sport is scarce. Therefore, the purpose of this qualitative interpretative phenomenological analysis was to examine parent–athlete interpersonal relationships in youth sport. The second aim was to gain an understanding about the importance of the athlete attachment to parents in youth sport.

Methods

Selection of research participants. The research participants were chosen from volunteers who answered the invitation to participate: parents of 16 year old athlete adolescents. Demographic data of research participants are presented in Table 1. In the survey that lasted for almost two years 8 stories of parents were voice recorde

Table 1. Demographic characteristics of athlete parents

Research participants (parents)	Age	Education	Child's sport	Child's athletic experience (in years)	Child's age
8	49.1	Higher	Individual sport	8	16

Research participants were selected basing on the following selection criteria: homogeneity, information coverage and informed consent to participate in the survey.

Selection of research and data analysis methods. Interpretative Phenomenological Analysis method, here in after IPA (Smith, 1996; Smith, Larkin, Flowers, 1996) was selected from all available qualitative research methods. IPA has a double purpose: it is both data collection and qualitative data analysis method (Smith, Larkin,& Flowers, (2009).

The process of the research. *Research procedure.* With the help of administration of sports clubs, information about the planned survey was announced in 7 sports clubs in Kaunas, Lithuania. Only interested in the survey parents collected flyers containing the description of the survey and researcher's contact details. 8 parents expressed the wish to participate. All 8 respondents were invited for an interview. Questions given to the respondents were formulated in accordance of the research problem. The plan of questions was followed in order not to digress from the research issue and at the same time not to restrict free associations of the respondents and the content of their stories. *Semi–structured interview.* Information about parent–athlete interpersonal relationships in sport was collected by means of semi–structured interview. This approach is considered to be an appropriate data collection method when the researcher attempts to het to the depth of meanings and the survey is first of all focused on insights and understanding.

Research data analysis. Data analysis was done in accordance with IPA methodological requirements (Smith et al., 2009). *Transcribing.* This stage enabled to get deep understanding of how respondents talked about themselves: their tone, speech rhythm, pauses, change of topics. IPA requires to have a detailed and full interview transcription (text), which is the object of analysis. The transcribed text must indicate certain interactions of interviewees (laugh, cry, silence, evident change of mood, etc.). Materials collected in 8 interviews – voice records (more than 8 hours) were transcribed into text. It took in average one week to transcribe one interview.

Ethical aspects of the survey. Survey respondents participated voluntarily and for no remuneration. They did not receive any misleading information regarding research goals or the form of results presentation. Research was conducted in accordance with the following principles (Sacks, Westwood, 2003): Right for protection from damage; right for safety; usefulness of the survey; privacy; confidentiality; fairness.

Research quality assurance. Researcher followed L. Yardley (2000) presented four principles of research quality assessment: a) sensitivity to context; b) researcher's reflexivity; c) research transparency and consistency; d) research relevance and utility.

Results

Parent–athlete attachment

During the conversations with adolescent–athlete parents, the general tendency was felt that parents, who have adolescents–athletes understand the adolescents' wish to be independent and desire to create their own identity. Parents were glad that, through their children participation in sports, parents are able to maintain parent–adolescent communication and relationship between them:

"It is good because you could talk with your child about different topics related with sport environment. I felt the pulse of what is going on in my teenager's life through talking about sport themes. That was how I found the way to be a little closer to her (daughter). The time when we talked about training classes, the time spent at my daughter's competitions and celebration important sport moments created very close relationship between us"

"Actually we have a very close connection from early childhood. I've been waiting my daughter until the workout is over. In the long run, we started to go to the training classes together. And that was terrific, it brought us even closer. But now I critically reflect myself and understand that if there were no close relationship since childhood between us, I am sure that today we were not be able to go to the same gym together. It is a long process which has to be created"

„Parent–child relationships directly influences the athletes ability to be accepted by friends and teammates, as well as coaches and even oponents. As I have athletic child, I now see that he is able to contact others, to be flexible and make healthy relationships, he is more communicative"

Secure athlete attachment to parents

The research showed that the expression of secure parent–athlete attachment and parental involvement into children's sports depends on how parents perceive the value of sport and how they transfer this perception into acquaintance with the child's sporting life. The interviewed parents acknowledged regretfully that parental involvement in the period of adolescence becomes less appreciated. However all parents emphasized that secure athlete attachment to parents appears only through harmonious parent engagement:

"It is the ability to back off and observe your athletic child from the side. You need to trust your children and not show too much emotions. A mother who shouting, gets into the conflicts with an athlete, coach, and referees – is a bad example and can negatively impact the relationship between the athlete–child and the parent"

"Parents who allow to decide in sport environment himself, and make his own decisions is an advantage. And the biggest mistake is when you try to interfere"

"The emotional support, the joy and pride of your athletic child without criticism, and without parent hope the child to be a champion, creates a very good and safe emotional connection not only between the athlete and the father, but also between family members as well"

Insecure athlete attachment to parents

The research showed that the form and degree of parental involvement into youth sport closely related with the parent–athlete attachment style. Athlete insecure attachment to parents occurs when parents applies psychological pressure and wish to fulfill their own dreams through their child. In addition, adolescents' attachment to sport may add to the alienation from family. Teenagers naturally rebel, try to escape from parental control, demonstrate independence, and thus sport becomes another precondition for alienation from parents. Athletic adolescents in the long run become more attached to sport, their coach and competitions. In the sporting life of adolescents the coach's authority can replace parental authority:

"Father chose the sport for the child. It was the fathers wish and it was his decision but not the child's"

"The coach is like a father. It seems to me now, as he (son) became a professional athlete, the coach becomes more and more important to him. It seems to me that the coach's authority is much more important than mine"

"Parents unsatisfied face, verbal and non verbal actions towards the athletic child... It is psychological violence. And more and more psychological violence is seen in sporting environment. Not everybody will see it. Your look can be much more painful than a punch. And only the addressee will see it. An outsider may not be aware. The child will not say that the dad or mom looked at me so that I clung to the wall and was very bad for me. He will not be able to describe it"

"Counting the medals and the victories, comparing your own child with others is the biggest mistake, and it will not motivate the child. It seems that parents want more and more. Unconditional love to the child usually leads to a burn out or drop out of sport result"

Discussion

The purpose of this qualitative interpretative phenomenological analysis was to examine parent–athlete interpersonal relationships in youth sport. The second aim was to gain an understanding about the importance of athlete attachment to parents in youth sport. *The first theme "Parent–athlete attachment"* described the parent and athlete ability to be closer together through the sporting environment. The parent–adolescent–athlete relationship in daily life changes, because of the growing child, and sport becomes another positive and beneficial activity which enables to be parents attached to their child. One of the most important predictors to be securely attached to athletic child –is the created early parent–child attachment and close relationship between them. Such early parent–child attachment enables to create trust, communication between them in the sport environment as well. Links between attachment and social acceptance emerged in this research as well. According to qualitative study results adolescents atheletes who are securelly attached to parents were more socially accepted by their peers, coaches, even oponents. This finding supports Bowlby's (1969) proposition that secure individuals will generally have more positive interpersonal relationships than insecure individuals. Negative influence is also connected mainly with insecure attachment style and beliefs of parents that their child has low sport competence and is not good enough to participate in sport. Nawaz (2011) study results analysis demonstrate that parents and peer attachment bonds together account for prediction of identity development among adolescents but peer attachment bonds serve as more powerful predictors of identity development in comparison to parental attachment bonds. Moreover, the second theme "Secure athlete attachment to parents" describes how secure relationship between the parent and the child occurs in sporting environment. The ability to observe the athletic child from the side seems to be the most important aspect in youth sport. To let the child to make their own decisions in sporting environment is of the highest importance which creates secure athlete–parent attachment in sport. The cross–sectional study by Sukys, Lisinskiene, Tilindiene, (2015) also showed that adolescents athletes are more attached to parents compared to non athletes.

The third theme "Insecure athlete attachment to parents" presents how insecure parent–child attachment in sporting environment appears. The general tendency during the interviews with youth sport parents was felt. The parents perceived behavior in sport environment could influence insecure attachment to athlete. Dawood Al Sudani, (2014) made a conclusion that negative influence is connected mainly with insecure attachment style and beliefs of parents that their child has low sport competence and is not good enough to participate in some kind of sport for example because of gender or low abilities. The current study results revealed that the quality of interpersonal relationships in early childhood has a direct influence of interpersonal relationships in adolescence. In addition, these relationships transfers into a adolescents athletes life and has a significant impact on athlete sport motivation, sporting career and continuity of sporting experience.

Conclusion

The phenomenological interpretative analysis has revealed the importance of the athletes attachment to parents in youth sport. Interviews with athlete parents revealed that involvement into children's sport is more important in the early period of youth sporting experience and become less appreciable or unwelcome when children gain sporting experience. Parents–child attachment in early childhood has an affect in youth sport participation. Secure attachment ensures a positive and safe development in children's sports: the child becomes confident, independent, goal–seeking, result oriented, able to regulate emotions in sport and easily integrates into a sporting environment. In contrast, insecure parent–child attachment leads to a athlete demotivation, disability to survive in a competetive environment which in tern can lead to a drop out of sport phenomenon.

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ANALYSIS OF FITNESS LEVEL OF SCHOOL-AGE CHILDREN IN THE CZECH REPUBLIC – THE SOCIO-ECONOMIC VIEWPOINT

Perič Tomáš

Faculty of Physical Education and Sport, Charles University in Prague, Czech Republic

Abstract

In connection with the Sazka Olympic multi-event competition there was implemented nationwide testing of more than 90.000 children at the age of 6-16 years in the school year 2016/2017.

Physical fitness was assessed through 8 motor tests and somatic characteristics with 2 indicators (body height and weight). Results were analysed in three main areas:

1. Comparison of fitness development – boys vs. girls
2. Comparison of fitness among individual regions
3. The relationship between economic indicators and fitness level
4. Availability of sports grounds.

We found the strong relationship (correlation) between economic indicators and fitness level and between availability of sports grounds and fitness. This correlation is essential especially for first level of primary school.

Key words: *testing, small and large settlements, boys vs. girls, comparison of regions*

Introduction

Nowadays we have the broad spectrum of possibilities of using leisure time. Movement activity in any form should be integral to everyday human life. Nevertheless the amount of performed movement activities is permanently decreasing. Bunc (2011) mentions about 30% decrease in two last decades. The use of movement activities not only in area of health support and disease prevention, but also socialisation and formation of attitudes of children and youth has the irreplaceable importance.

Despite the known benefits of movement activities for human health there recently appear many children that move only during school lessons of physical education. Researches show that 70% of school children and youth spend more than four hours a day of their leisure time by sitting by computers, surfing the Internet, watching TV, playing computer games and distraction with mobile phones. Only every third pupil is engaged in regular organised movement activity.

The studies show that spontaneous activity decreases in period of adolescence, mainly by girls after their 14 years of age and by boys between 16 and 18 years of age (e.g. researches of Sigmundová, Suchomel, Rychtecký and the like). The comparison of results from monitoring of the work and rest regime, which was conducted in years 1999 and 2012, showed that pupils spend nowadays less time outdoors. While in the year 1999 almost 80% children, both from the cities and villages, mention that they spend more than two hours a day outdoors, in the year 2012 it was only 30,4% of city children and 60,5% of village children. These findings document the negative trend in lifestyle of current children and youth (Bunc, 2011).

Socioeconomic status

Socioeconomic status strongly correlates with range of indicators of personality, performance, career, self-promotion and life success rate (also school one). Its base is formed by social class into which the individual belongs, mainly on the basis: his/her job prestige, income (wealth), education (Helus, Z., 2007). Mota & Esculcas (2002) mention that prevalence of overweight together with unhealthy lifestyle connected with lack of movement activity are higher by children from families with lower socioeconomic status, while children from families with higher socioeconomic status have positive attitudes to performing movement activities, higher level of fitness and higher share in organized movement activity. This is also confirmed with the result of the Hanson – Chen (2007) study. Authors pointed out that lower socioeconomic status is connected with worse eating habits and lower amount of performed movement activity.

Infrastructure for movement activity

Researches prove (Sallis, Story, & Lou, 2009) that environmental conditions, mainly in place of residence and attended school, can influence movement habits of a child and also the amount of performed movement activity. Also Sallis – Prochaska – Taylor (2000) confirmed positive correlation between accessibility of sport facilities and playgrounds with performance of movement activity by children and youth.

The facts mentioned above show that there exist many confirmed findings about low level of performance of movement activity by current population of children and youth, but only general assumptions about the important influence of socioeconomic status of the family and sport infrastructure for encouraging to performance of movement activities of children.

Methods

In connection with the Sazka Olympic multi-event competition there was implemented the nationwide testing of more than 90.000 children at the age of 6-15 years in the school year 2016/2017. Physical fitness was assessed through 8 motor tests and somatic characteristics with 2 indicators (body height and weight). Results were analysed in four main areas:

5. Comparison of fitness development - boys vs. girls
6. Comparison of fitness among individual regions
7. The relationship between economic indicators and fitness level
8. Availability of sports grounds

The research was implemented at elementary schools in the Czech Republic in period from December 2016 to June 2017. More than 200,000 children were involved in the research; all data (8 motor tests, 2 somatic indicators and 2 geographical indicators) were gained from 90 52 283 school-age children. Specific age and gender cohorts are presented in table 1.

Table 1. Age and gender distribution

	Age											
	6	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Boys	1552	5746	6447	6573	6242	5537	4214	4032	3776	2579	302	47000
Girls	1990	5810	6211	6240	5887	5040	4141	3964	3688	2126	186	45283

The measurement was carried out during lessons of school physical education by teachers of physical education. The involvement to the research was for the individual schools (teachers) and probands (pupils) voluntary - within the program of the Sazka Olympic multi-event competition. When they got involved in the program the individual teachers got instructions about the organization, timetable and test evaluation via instructing videos. In case it was not clear the teachers could visit instructing seminar that took place in every region.

Data structure

We divided the research data gained from the individual probands to four basic groups:

1) **Identification data** – ID of the child, age and gender
2) **Somatic parameters** - Body height and weight

3) **Fitness tests** - stork stand, sit and reach, truncated sit-ups, T-Run, 60m run, 500m run (6-11 years old) /1000m (12-15 years old) run, long jump (6-11 years old) / triple jump (12-15 years old), basketball throw
4) **Geographical data** - Place of residence – region, size of the settlement

Results and discussion

Comparison of fitness development – boys vs. girls

When evaluating development of fitness we worked with arithmetical means of the individual age and gender cohorts and we compared them in graphs.

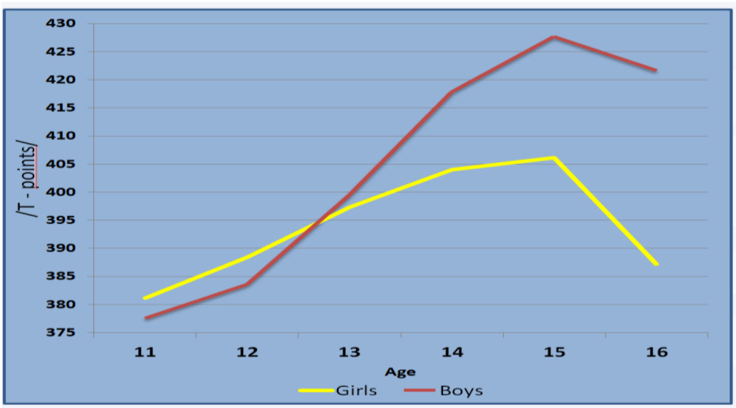
The results of the individual tests show that girls **exceed boys more in the following events**: stork stand (balance) and sit and reach (flexibility); **boys exceed girls in the other abilities**: T-Run (agility), 60m run (speed), basketball throw (explosive power), long jump (explosive power) 500/1000m run (endurance). For **power endurance – truncated sit-ups** girls exceed boys in the first stage of elementary school (1^{st} – 5^{th} grade) and the ratio is reversed in the second stage of elementary school (6^{th} – 9^{th} grade).

Results in most tests correspond to presumptions of gender differentiation between boys and girls – girls are better in balance and flexibility, boys in speed, strength and endurance. It was quite surprising that girls below the age of 12 years achieved better results in truncated sit-ups and boys start to be dominant in this test just after the age of 12 years. This result is more interesting because of the boys in all age categories are better in other test items concerning strength abilities (basketball throw and long jump/triple jump). In this context we have not found out the explanation of this result yet. It will be surely interesting, if we find out similar results in following years of the research.

The overall level of fitness of boys and girls was evaluated in connection with the results in individual tests. Raw scores in individual tests were transformed to normalized scores (T-scores were used) and they were counted up. Results of the sum of individual tests in the whole test battery were understand as indicator of fitness level.

While the results in the first stage of an elementary school showed that there are not significant differences between boys and girls, we had very interesting findings in the second stage of an elementary school – see picture 1.

Figure 1. Comparison of development in the 2nd stage of an elementary school



In the picture we can see that at the beginning of the second stage of an elementary school girls achieve little bit higher level of fitness than boys. But the differences are not significant (it is about ac. 4 T-scores). This higher fitness can be caused by higher maturity of girls in this age (earlier beginning of the puberty). After the age of 12 years boys already have higher performance than girls. The very interesting thing is to look at the results around the age of 15 and 16 years. The very fundamental decrease of fitness appears by girls in this age even up to fitness level of 12 years old girls.

Very important question is the reason of this decrease, which has probably not the biological reason (sport practice shows that competing of e.g. 14 and 16 years old girls in athletics is not comparable). It is more about the problem of lower motivation in connection with gender and biological changes but also with possible changes in value orientation.

Evaluation of fitness level in the individual regions of the Czech Republic

In connection with results from evaluation of fitness level we conducted also the analysis of fitness level in connection with geographical distribution of the Czech Republic to higher administrative units – regions. To be able to compare results in the individual test items (and in individual age and gender cohorts) we transformed them to normative score (T-scores) and the individual regions were compared through the total sum of all eight test items. On this basis we made the arithmetical mean of the individual regions and compared mutually all of them. The results of the mean value of the individual regions (that are compared to averages of previous two years of Sazka Olympic multi-event competition) are presented in table 2.

Table 2. Regions ranking according to fitness level

Regions	2016/2017	2015/2016	2014/2015
Prague	**476**	**490**	**415**
Liberec	**453**	**439**	**453**
Pardubice	**431**	417	408
Zlín	415	**419**	**446**
Central Bohemia	400	<u>*368*</u>	392
South Moravia	400	394	400
Ústí nad Labem	392	<u>*376*</u>	385
Moravia-Silesia	392	392	400
South Bohemia	385	413	408
Hradec Králové	377	380	400
Vysočina	370	375	**415**
Karlovy Vary	<u>*362*</u>	376	<u>*370*</u>
Pilsen	<u>*354*</u>	<u>*373*</u>	<u>*331*</u>
Olomouc	<u>*354*</u>	387	<u>*370*</u>

Note: Regions are compared according to ranking in the year 2016/2017. The first three regions in the year are marked with bold font, the worst three regions are written in underlined italics.

For the evaluation of stability of results in fitness level in individual regions we correlated results of individual years – see table 3.

*Table 3. Regions ranking of fitness level stability (*p=0,01, **p=0,05)*

Year of measurement	2016/2017 – 2015/2016	2015/2016 - 2014/2015	2014/2015 - 2016/2017
Correlation coefficients	0,87*	0,58**	0,70*

In table 3 we can see quite high degree of stability in ranking of individual regions that can be one of indicators of relationship between fitness level of children and socioeconomic indicators.

The relationship between economic indicators and fitness level

When we evaluated the relationship between socioeconomic indicators and fitness level, we used data that are provided by Czech Statistical Office. We chose four fundamental indicators from these entries, which could in a certain way determine the sport possibilities for children:

a) Gross domestic product (GDP) per capita,

b) % of unemployment,

c) % of university educated people,

d) average age.

By these four indicators we found the average values for the individual regions and they were compared by correlation coefficient with the fitness level in individual regions.

The results are shown in table 4.

Table 4. The relationship between economic indicators and fitness level

Economic indicator	**Age group**			
	6-8	**9 -11**	**12 - 13**	**14-16**
GDP/per capita	0.62	0.68	0.33	0.18
% university degree	0.65	0.65	0.33	0.18

Note: In table 4 there are mentioned only the indicators by which the statistical significance of correlation coefficient on the level of p=0.01 was found at least by one age group.

From the results we can see the quite high correlation between the fitness and economic level in a certain region. Also the percentage of university educated people correlates with fitness level. These values are significant primarily in the first stage of an elementary school.

In connection with results shown in table 4 we approached to evaluation of fitness and socioeconomic indicators as agglomerated variable. It was done by multiple correlation. Results of the analysis are shown in table 5.

Table 5. The relationship between economic indicators and fitness level - total

	Age group					
Economic indicators	**6-8**	**9 -11**	**12 - 13**	**14-16**	**1st level Total**	**2nd level Total**
	0.66*	0.70*	0.60	0.45	0.77*	0.54

Note: * statistical significance of correlation coefficient on the level of p=0.01

The similar conclusion as from table 4 is emerged from table 5. The relatively high correlation between higher level of socioeconomic indicators and higher level of fitness in a certain region is evident primarily in the first stage on an elementary school.

Relationship between availability of sports grounds and fitness

In connection with investigating the relationship between fitness and accessibility of sports grounds the correlation analysis was implemented. We used information form the project of the Czech Olympic Committee "Sport in neighbourhood". On the basis of this database of sport clubs fitness level of children was correlated with the number of sport clubs in the distance from their school. It was done in three levels:

a) Up to 1 km – distance accessible on foot,

b) up to 5 km – distance accessible without problems with city transport or riding a bicycle,

c) up to 15 km – distance accessible without problems by car.

The results of correlation analysis are shown in table 6.

Table 6. Relationship between accessibility of sports grounds and fitness

Number of clubs within the distance of	**Age group**			
	6-8	**9 -11**	**12 - 13**	**14-16**
1 km	0.51*	0.64*	0.39	0.46
5 km	0.66*	0.73*	0.38	0.27
15 km	0.65*	0.72*	0.37	0.22

Note: * statistical significance of correlation coefficient on the level of p=0.01

From the table 6 it is again evident the significant correlation between accessibility of sports grounds and level of fitness, primarily in the first stage of an elementary school.

Conclusions

The analysis of fitness level of school-age children in the Czech Republic brought range of interesting findings and data.

In connection with evaluation of fitness level and socioeconomic indicators in regions we could accept following main conclusions:

- Confirmed relationship between fitness and economic conditions - higher fitness:
  - Children from "richer" regions
  - Children with better access to sports clubs

- Children stop doing sport spontaneously and their physical activity is tied to organized (commercial) sports
- The issue of the social policy of the state, the higher self-governing units and municipalities in relation to children's fitness
- Essential influence mainly at first grade of primary school
- An alarming drop in fitness at the end of puberty (**especially in girls**)

In connection with following funding and data collection it will be interesting to compare results in particular years and also in the longitudinal context. High number of probands and broad focus on socio-cultural area give good preconditions for finding other connections with development of fitness level of school-age children.

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PHYSICAL ACTIVITY OF WOMEN OF WORKING AGE, INCLUDING EARLY SENIOR AGE, IN THE LIGHT OF THEIR FREE CONSUMPTION BUDGET

Puciato Daniel[1], Markiewicz-Patkowska Julita[2], Oleśniewicz Piotr[1], Widawski Krzysztof[3], Krzepota Justyna[4]
[1]University School of Physical Education in Wrocław, Wrocław, Poland
[2]WSB University in Wrocław, Wrocław, Poland
[3]University of Wrocław, Wrocław, Poland
[4]University of Szczecin, Szczecin, Poland

Abstract

The aim of the study is an attempt to determine the relationship between physical activity and the size of the free consumption budget in women aged 18–65 years from Wrocław (Poland). The total of 1894 women aged 18–65 years took part in the study conducted in 2014. The International Questionnaire on Physical Activity in its short version was used to assess physical activity. Furthermore, information was collected on the following: age, free consumption budget, as well as body height and weight of the respondents, which were then used to calculate BMI. Statistically significant and positive correlations between the total and moderate physical activity of the examined women and the size of their free consumption budget were observed. The results obtained indicate that the free consumption budget may be a better predictor for physical activity than other economic variables, such as gross income. However, to verify this assumption, further research into the economic determinants of physical activity is necessary.

Key words: *motor activity, free consumption budget, WHO*

Introduction

Currently, physical activity is an increasingly important sign of cultural behaviours in contemporary human beings, and the leisure industry, including recreation, tourism, sport, culture and entertainment, is one of the fastest growing areas of world economy. People in working age who are professionally active are increasingly demanding for the kind of services which would enable them to actively relax and regenerate their strength (Puciato et al., 2013).

Undertaking physical activity also is, in addition to a rational diet, one of the main components of the so called healthy lifestyle, which has a positive impact on the quality of human life in physical, mental and social terms (Bernabe et al., 2016; Krzepota et al., 2015; Marlow & Shiers, 2012; Mcaleese et al., 2016; Skrzek et al., 2015). The shortage of physical activity increases the risk of developing civilization diseases such as: obesity, type 2 diabetes, osteoporosis, ischemic heart disease, musculoskeletal disorders, depression or certain types of cancer (Choi et al., 2010; Fransson et al., 2004; Grove & Welders, 2009; Kohl, 2001; Mynarski et al., 2015; Nawrocka et al., 2014; Schneider & Becker, 2005; Wróblewska et al., 2015). The prevalence of these diseases in people of working age has major economic implications because of huge costs associated with their treatment, absence from work and poor productivity during recovery (Puciato et al., 2013). Therefore, public health programs in many countries are aimed at improving lifestyles, including increasing physical activity to a level that would have a positive impact on health. To this end, the World Health Organization recommends physical activity of a moderate intensity for 150 minutes or high intensity for 75 minutes per week. Physical activity of this kind should also be accumulated in at least 10-minute intervals of time (World Health Organization, 2014).

Regarded as a cultural phenomenon, physical activity can be modified in some way by such socio-economic factors as: age, sex, place of residence, education, as well as professional and material status. With regard to women, although the links between physical activity and social factors are quite well documented (Gerovasili et al., 2015; Ignasiak et al., 2013; Puciato, 2016), the directions of the impact of material status on their physical activity are not fully understood. On the one hand, less affluent women are more likely to make physical effort as part of their professional work. On the other hand, women who are better off materially are usually better educated as well, and thus more conscious of the role of physical activity in their health. In addition, more and more physical activity forms are currently paid, and this also puts affluent women in a better position. Also, the results of previous empirical research in this field were not unequivocal. The works of Biernat (2015) and Choi et al. (2010) noted an increase in physical activity with the improvement of the economic status, and the works of Da Silva et al. (2015) and Puciato (2015) showed multidirectional correlations between physical activity and economic status.

Also, former papers did not consider material status in the context of net disposable revenue per capita, that is the so called free consumption budget. This is the amount of money that is available after all basic expenses have been paid, such as: taxes, bills, food, clothing, transport to work, etc. Addressing this specific research gap is the main task of the article, whose cognitive purpose is to attempt to determine the relationships between physical activity and the size of the free consumption budget in women aged 18–65 from Wrocław, Poland.

Material and research methods

The study conducted in October 2014 included 1894 women aged 18–65 years, representing about 1% of women of this age living in Wrocław. Quota sampling was used, whereby: (1) control characteristics of the population were determined – sex and age, as well as groups (quotas) of population components corresponding to the structure of the Wrocław community; (2) the selected quotas were divided among interviewers. Among participants, there were 645 (34.05%) women with monthly disposable income lower than 50 euros, 603 (31.84%) women with income between 51 and 100 euros, and 646 (34.11%) women with income above 100 euros. All respondents were informed about the purpose and the procedure of the research and agreed to participate in it. The research project received a positive opinion from the Bioethical Committee of the University School of Physical Education in Wrocław, Poland.

A diagnostic survey method was used to assess the habitual physical activity – the auditorium questionnaire technique. The short version of IPAQ questionnaire was a survey tool, including six questions on the physical activity of respondents in a typical week of their life. The activity considered in the study included physical efforts as part of the professional work, at home and around the house, while traveling from one place to another, and in free time. The study analysed in detail the responses addressing the self-assessment of the frequency and duration of physical efforts categorized into three intensity types: high, moderate and low intensity. Effort intensity was determined with metabolic equivalent, MET (1 MET corresponds to the consumption of O_2 at rest and equals 3.5 ml of O_2/kg body weight/min), where MET of 3.3 was assumed for low intensity, 4 for moderate, and 6 for high intensity. The calculation algorithm consisted in multiplying the number of days, duration and the mentioned metabolic equivalent values separately for each effort intensity type.

In the course of the study, information was also gathered on age, height and body weight to calculate BMI, as well as information on free consumption budget. The following statistical characteristics were also calculated: arithmetic means, standard deviations, variation coefficients, minimum and maximum values, and Kruskal-Wallis ANOVA test. The statistical conclusions were drawn with $p < 0.05$. The calculations were made with IBM SPSS Statistics 20 computer software.

Survey results

Table 1 shows the basic statistical characteristics of the women surveyed in terms of their free consumption budget. In each analysed group of respondents, the low intensity efforts were predominant, and the high intensity efforts had the smallest representation.

The declared time spent on physical activity in the studied women from Wrocław increased with the increase of the free consumption budget at their disposal. However, statistically significant differences were observed only in relation to total weekly physical activity and moderate physical activity. For total weekly physical activity, the average weekly duration of physical activity in the lowest-income women was 488.6 minutes, in moderate-income women was 542.9 minutes, and in the highest-income women was 565.4 minutes. The moderate physical activity undertaken by women with the lowest income took 181.1 minutes per week on average, by women with moderate income – 219.2 minutes per week, and by women with the highest income – 243.3 minutes per week.

Whereas differences in physical activity of low and high intensity among the groups of women isolated according to the free consumption budget were not statistically significant. These results were obtained even though the arithmetic mean of the age of respondents increased statistically significantly with the increase of the free consumption budget. For the somatic parameters analysed in the study, i.e. body height and weight, and BMI, no statistically significant differences among the groups isolated according to the free consumption budget were marked.

Table 1. Diversity in variables in the surveyed women with different levels of the free consumption budget

Variable	Free consumption budget [euros]	$\bar{x}$	SD	V	Min	Max	H	p
Age [years]	≤ 50	38.9	13.7	35.1	18.0	61.0	21.83	**0.000**
	51–100	40.9	14.2	34.8	17.0	64.0		
	> 100	42.4	13.5	31.9	16.0	63.0		
Body height [cm]	≤ 50	166.3	6.1	3.7	150.0	185.0	5.92	0.052
	51–100	166.7	8.1	4.9	151.0	192.0		
	> 100	165.3	6.8	4.1	148.0	190.0		
Body weight [kg]	≤ 50	64.1	10.2	15.9	38.0	96.0	0.57	0.751
	51–100	64.4	9.8	15.2	42.0	95.0		
	> 100	64.5	10.5	16.3	38.0	97.0		
BMI [kg/m^2]	≤ 50	23.2	3.5	15.0	14.3	33.2	4.20	0.122
	51–100	23.2	3.4	14.5	16.4	32.3		
	> 100	23.7	4.1	17.1	14.3	40.0		
Duration of high-intensity physical activity [min/week]	≤ 50	178.7	112.0	62.7	15.0	450.0	0.50	0.778
	51–100	179.1	121.0	67.5	25.0	450.0		
	> 100	179.1	114.5	63.9	10.0	630.0		
Duration of moderate-intensity physical activity [min/week]	≤ 50	181.8	117.4	64.6	10.0	600.0	27.49	**0.000**
	51–100	219.2	135.9	62.0	30.0	630.0		
	> 100	243.3	173.7	71.4	20.0	840.0		
Duration of low-intensity physical activity [min/week]	≤ 50	259.4	157.1	60.6	10.0	840.0	5.69	0.058
	51–100	268.2	120.4	44.9	20.0	630.0		
	> 100	280.4	187.8	67.0	10.0	840.0		
Overall duration of physical activity [min/week]	≤ 50	488.6	294.2	60.2	40.0	1440.0	16.93	**0.000**
	51–100	542.9	244.4	45.0	80.0	1350.0		
	> 100	565.4	379.1	67.0	10.0	1920.0		

Discussion

The need for a research on physical activity results mainly from the important role of physical activity for health and quality of life. This is all the more important as there is a shortage of exercise in many societies, as confirmed by numerous scientific studies. This problem affects also Poland, because according to the study carried out by Gerovasili et al. (2015), only 56% of the population of Poland have sufficient physical activity in terms of positive health effects. This study showed Poles as one of the least physically active nations in Europe, as the mean value for the whole population of the European Union was 71.4%. Women deserve special attention in physical activity research, as according to research they are considerably less physically active than men (Elkjaer et al., 2006; Mynarski et al., 2014; Rożek-Piechura et al., 2014).

Among the female respondents from Wrocław, the prevalence of low intensity efforts in weekly activity structure was noted, which was already known from previous studies (Biernat, 2015; Ignasiak et al., 2013; Mynarski et al., 2015; Puciato, 2016; Puciato et al., 2013). This phenomenon can be dangerous as the positive impact of physical activity on human health relates to sufficiently high volume, frequency and intensity of activity (Mynarski et al., 2012; Nawrocka et al., 2014; Schneider & Becker, 2005; Stemplewski et al., 2012; Teoman et al., 2004). On the other hand, physical activity of low intensity may not be a strong enough stimulus to maintain or improve health. This is particularly important with respect to women, in which the low intensity physical activity share in the overall physical activity is much higher than in men (Puciato, 2016).

Positive correlation between the moderate and overall physical activity of the examined women with the size of their free consumption budget were observed. This was noted despite the fact that the arithmetic mean of the age of respondents increased statistically significantly with the increase of the free consumption budget. This confirms the indicated correlation of physical activity with the size of the net disposable revenue per capita, as the empirical studies clearly show that physical activity levels tend to decrease with age (Gerovasili et al., 2015; Ignasiak et al., 2013; Puciato, 2015; Schneider & Becker, 2005). Statistically significant and positive correlation between the economic status of women was also recorded in the papers of Biernat (2015) and Choi et al. (2010). This may indicate the growing importance of physical activity in free time in the structure of the total human physical activity. Women with a higher material status can afford the expenses related to paid forms of physical recreation, including purchase of season tickets for recreation centres, purchase of sports and leisure equipment, bearing costs of transport for recreational activities, or possibly accommodation outside the place of permanent residence. Whereas people with lower income must often take an additional job, which reduces their leisure time resources and can negatively affect the work-leisure balance. Such a situation may increase the level of stress and cause psychosomatic disorders, and consequently decrease the interest in physical activity, which could further intensify these adverse symptoms. In the context of these observations, it is therefore necessary to include less affluent people in public health programs aimed at increasing the level of physical activity.

The analysis of the results of the conducted study enables the identification of both strengths and weaknesses of the article. Among the strengths of the work is the tested group, because the economic determinants of women's physical activity have rarely been analysed. Another strength of the article is the assessment of the economic situation of the respondents in the light of their net disposable revenue.

It may be assumed that it is the net disposable revenue and not the gross income which determines the actual capacity to spend money on physical activity. It may happen that despite relatively high gross income, respondents would spend so much on their basic needs that their free consumption budget would be tiny or non-existent. Expressing the material status in terms of the net disposable revenue per capita eliminates this methodical problem.

The weak points of the article are limiting the examined population to women from Wrocław and the use of an indirect method of physical activity evaluation. Subsequent studies should therefore extend the spatial scope of the research to the whole area of Poland and possibly other countries, and apply other methods of studying physical activity (such as long version of IPAQ questionnaire, pedometry or accelerometry).

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THE LEVEL OF INCLUSION FOR STUDENTS WITH VISUAL IMPAIRMENT IN THE CZECH REPUBLIC

Růžičková Kamila, Růžička Ivan
Faculty of Education, University of Hradec Králové, Czech Republic

Abstract

Over the last twenty five years, the inclusion of pupils and students with visual impairment has been possible in the Czech Republic. It is necessary to find actual situation in practice to evaluate the benefits and risks of current methods and supportive strategies. The aim of this paper is focused on charting the actual level of inclusion of pupils/students with visual impairment aged 7 to 18 years in physical education. This data is important to upgrade the quality of inclusion in Czech schools.

A quan/qual research design was used in research surveys. The research group consists of experts - special education teachers and advisers and physical education teachers at primary and secondary schools in the Czech Republic, who teach pupils with visual impairment. We concentrate on the assessment of teachers' competence in support strategies and in the quality of environmental conditions; assessment of the level of use of support aids and strategies for the education; assessment of the level of teachers' experience and regarding the subject of PE and level of support from experts from regional support center for pupils/students with visual impairment.

The results show that the level of education and provision of support measures is still unsatisfactory in a large number of schools. Based on the results, the following recommendations are formulated: To improve the awareness of schools about the possibilities of education and to support the motivation of teachers for their completion. It is also necessary to increase the number of teaching assistants for the subject of PE and/or reduce the number of pupils in PE lessons. It is also important to ensure control activity in schools concerning the provision of support measures, including aids and environmental adaptations for which schools annually receive finances.

Education of primary school pupils in the area of locomotor development should be regarded essential for future exercise regimen and prevention of lifestyle diseases. Pupils with visual impairment belong to the risk group of persons with lack of movement. But majority of pupils with visual impairment are educated inclusively; however, researches focused on the quality of physical education lessons in the Czech Rep. have not been implemented yet. The research results will become the basis for monitoring the development of quality of education following the new legislative norms

of the Education Act. The basic anticipated reflection of the new legal system is an increase in the number of pupils with VI participating in PE and introduction of further support measures into PE lessons. Moreover, the results will help create special means of support for teachers at mainstream schools to educate pupils with visual impairment.

Key words: *adults; low vision; visual rehabilitation; reading performance; adaptation of external conditions; research.*

Introduction

Motor development is linked with visual perception. Visual stimuli are a major source of motivation for motor and cognitive development. Through sight, children create an idea about their body, body movements and the environment. (Adolph, 1997) Individuals with visual impairment (VI) cannot form accurate ideas of the world, and the development of their perception and cognition is affected. (Růžičková, 2006) Following Prechtl, Cioni, Eindpieler, Bos, & Ferrari (2001), vision conveys a significant feedback also to vestibular and proprioceptive system. This feedback is missing in children with VI. The absence of visual stimuli makes the perception of one's own body and surrounding world incomplete, less accurate and qualitatively different. As a consequence, inefficiently performed physical skills may occur. (Janečka, & Bláha et al., 2013) The research of Kozub & Oh (2004) has shown that children with VI become less active as they get older. Teaching of the subject of physical education (PE) should prevent incorrect posture and support faultless movement stereotypes. (Růžičková, 2015) In recent decades, the quality of physical education in schools has been often discussed also in connection with the need of education on healthy lifestyle with sufficient physical activities. (Abu-Omar & Rutten, & Robine (2004)

Inclusion in education is implemented since 1990 in the Czech Republic (CR). Today, therefore, its development draws from 25 years of experience. Czech legislation strongly supports the trend of inclusive education of pupils with special educational needs (SEN). It deals mainly with improving quality of support providing measures in schools in order of national and international such as Law on Preschool, Primary, Secondary and Tertiary Education (561/2004 Sb.), Standard rules on the Equalization of Opportunities for Persons with Disabilities (UN) or Global strategy on Diet, Physical Aktivity and Health. (Ispah & Gapa, 2010)

Support for the education of pupils with VI is ensured by Special Education Centres for Children with Visual Impairment (SECVI). This Centres are responsible for methodological support of the teachers and provide training in specific skills such as orientation and mobility.

At present, we are in the period of revision of the system of support for pupils/ students with SEN. They are newly defined by the amendment to the Education Act (561/2004), which came into force in the school year 2016/17.

Methods

The basic aim of the research is to map the current state of quality of physical education in mainstream schools which pupils with severe degree of visual impairment. The research continues on research survey of Škopová (2015) and Janečka, & Bláha et al. (2013). The research utilized a mixed research design. The data were obtained through non-standardized questionnaire and interview, which were created based on new Czech legislation (2016) and methological manuals on creation of Individual education plans pro for pupils with VI. Results of these research will be a basis for monitoring the development of quality of education according to the new legislation norms. Specifically, the following criteria of quality are to be assessed (Bartoňová & Ješina, 2012):

a) The level of pupils' involvement in PE;
b) The level of teachers' competence in the education of pupils with SEN;
c) The level of providing support measures in PE teaching;
d) The risks of full involvement of pupils with VI in PE.

The research group was constituted of PE teachers who include in their lessons pupils with VI in primary schools and of experts teachers and rehabilitation counsellors. To meet the above listed objectives, the following hypotheses have been set (H 1-3):

More than 75% of schools provide the included pupil with VI with an adequate level of involvement in PE.

More than 75% of teachers use support measures enabling active involvement of pupils with impairment in PE.

More than 75% of PE teachers, teaching a pupil with VI, are professionally competent.

The questionnaire survey addressed 151 elementary mainstream schools attended by pupils with VI. The questionnaire was filled by PE teachers. The questionnaire was answered by 108 respondents. The real situation was assessed of 153 pupils with VI. The data of factual nature were detected by semi-closed and closed questions. The opinions of teachers were mapped by means of scaled responses and open questions. The research group for the detection of qualitative data was represented by experts - SECVI employees (i.e. 14 specialists from the fourteen regions of CR). Interviews mediated additional questions for the evaluation of real situation in PE teaching in mainstream Czech schools.

Results

The chapter is structured into 6 parts. The first two provide input data on the selected sample of PE teachers and the characteristics of pupils with VI who were assessed during the research. The following parts represent a distribution rate of the participation of pupils in PE, the level of use of support measures, awareness of teachers about SEN of pupils and their views on problems which threaten the quality of education of pupils. The last part provides opinions of experts from SECVI on the quality of PE teaching of pupils with VI.

Input data on teachers of pupils with disability (n = 108)

108 respondents participated in the questionnaire survey, of which 82 (75.93 %) were women and 26 (24.07 %) were men. Teachers of all age groups were represented among those interviewed (more in Tab. No 1). The average age of respondents was 42.70 years. The overwhelming majority of 99 respondents (91 %) can be considered experienced teachers with more than six years of teaching practice (Tab. No 2).

Table 1. Age distribution of res. group (n = 108)

Age of PE teachers	Number/%
from 21 to 30 years	15/13.88
from 31 to 40 years	30/27.78
from 41 to 50 years	30/27.78
from 51 to 60 years	30/27.78
from 61 to 70 years	3/02.78
In total	108/100.00

Table 2. Average teaching experience of res. group (n = 108)

Years of teaching experience	Number/%
from 1 to 5 years	9/08.33
from 1 to 5 years	22/20.37
from 1 to 5 years	77/71.30
In total	108/100.00

Input data on pupils with VI (n = 153)

The research group of observed pupils with VI represented 153 individuals. In Table No 3 are given number of pupils/students of primary and secondary school and degree of VI.

Table 3. Degree of VI and number of observed pupils (n = 153)

Degree of reduction of visual ability in pupils	Moderate VI number/%	Severe VI number/%	Blindness number/%	Total number/%
Primary school	51/56.04	22/24.18	18/19.78	91/60.13
Secondary school	30/48.39	24/38.71	8/12.90	62/39.87
In total	**81/52.94**	**46/30.07**	**26/16.99**	**153/100**

One of the reported problem areas is the number of pupils in classes. Distribution within the monitored research group of pupils/students is given in Table No 4.

Table 4. Number of pupils in PE class (n = 153)

Number of pupils in PE class	Number	%
more than 24 pupils	20	13.07
20 – 24 pupils	52	33.99
15 – 19 pupils	52	33.99
10 – 14 pupils	15	09.80
less than 10 pupils	14	09.15
In total	**153**	**100.00**

Level of involvement of pupils with VI in the subject of PE

Approximately half of the pupils (50.33 %) are actively involved in PE lessons. 33.67 % of pupils are involved in the vast majority of activities. Instead of risky activities, alternative activities are chosen; or the pupil helps with the organization of activity. 11.76 % of pupils do not participate in the group education of PE, but have another organized form of locomotor development (mostly individual training of orientation and mobility with experts teacher). 3.93 % of pupils not attend any school-organized form of PE for reasons of health (Fig. No 1).

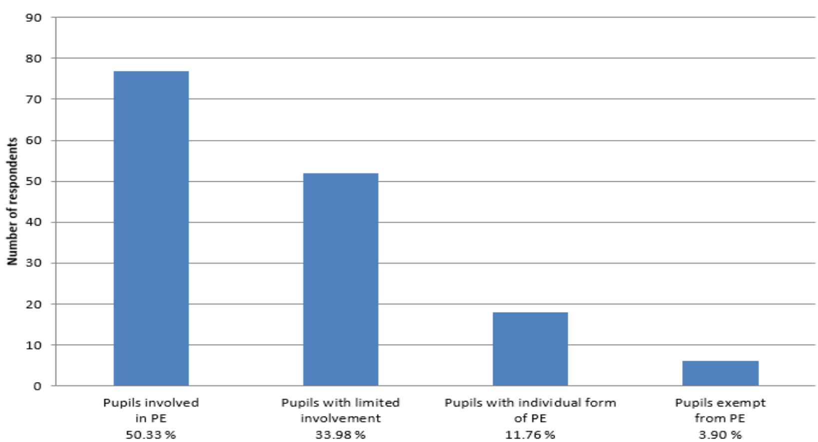

Figure 1. Level of involvement of pupils with VI in the subject of PE

Level of provision of support measures in PE teaching

83 teachers (86.12 %) use special approaches in teaching. In contrast, 15 (13.88 %) do not use any special approaches. The most frequently used approach is *precise verbal description*, which is used by 78 teachers (72.22 %). *Individual approach* is used by 69 teachers (63.89 %). 35 (32.40 %) respondents have reported the inclusion of *activities with adaptive sports equipment*. 25 (23.15 %) use the method of *tactile viewing*, 20 teachers (18.52 %) use the *method of facilitated movement guidance* and 4 (3.70 %) reported also the *help of classmates*. 5 respondents (14%) do not use any special educational approaches in PE lessons (Fig. No 2).

Another observed area concerned adaptive sports equipment. 94 teachers (50.00 %) use adaptive sports equipment. 42 (38.90 %) stated that they did not use any aids; 12 (11.10 %) did not use any aids because their pupils were exempt from PE. The most frequently used aids in PE lessons are given in Fig. No 3.

The last observed area is environmental adaptation. Special adaptations of gyms and other premises, where PE is taught, were implemented by only 6 teachers (5.56 %). In contrast, 102 teachers (94.44 %) does not use any special adjustments of PE premises.

Level of teachers' competence for teaching pupils with VI

A sufficient overview of the pupil's documentation and knowledge of limits and contraindications for his/her participation in PE was shown by 81 teachers (75.00 %). In contrast, 27 teachers (25.00 %) were not sufficiently informed about the conditions and limitations of the pupil. The awareness of SEN of pupils with VI is shown in Fig. No 4. Teachers obtained them most frequently from the experts of SECVI - in 89 (82.41 %) cases. 39 respondents (36.11 %) indicated professional literature as the source of information. 34 teachers (31.48 %) indicated their university studies and 9 (8.33 %) named school leadership as the source of information. 2 (1.85 %) were informed by a parent of the pupil. As to the issue of available educational courses, only 8 persons (7.41 %) consider the offer of education sufficient. 76 respondents (70.37 %) consider it insufficient and 24 (22.22 %) are not informed about training opportunities. 101 teachers (93.52 %) have not participated in any such training yet.

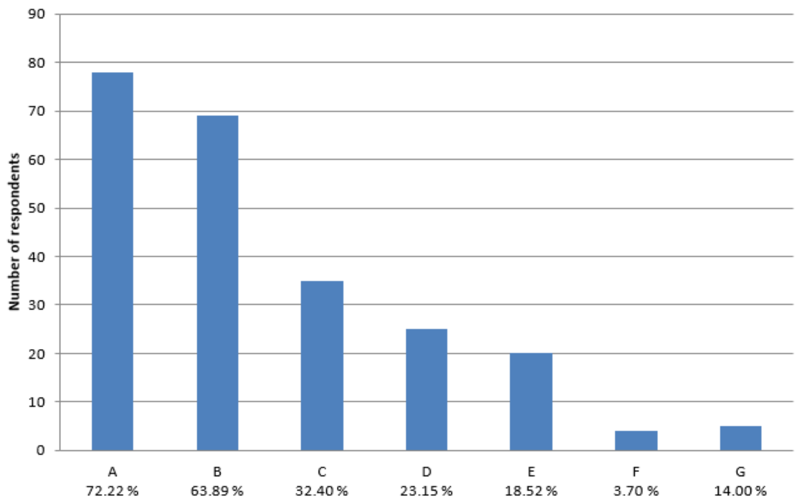

Figure 2. Most frequently used special approaches
(A – Verbal description; B – Individual approach; C – Activities with adaptive sports equipment; D – Tactile viewing; E – Facilitated movement guidance; F – Help of classmates; G – No special approaches)

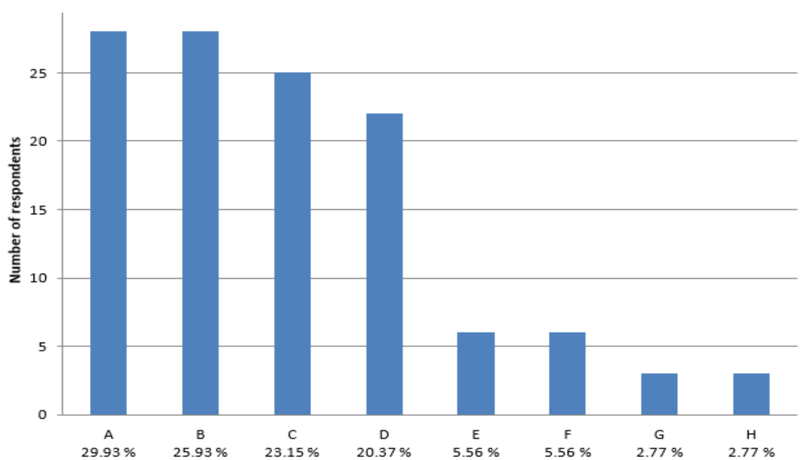

Figure 3. Used adaptive sports equipment
A – Sound balls; B – Contrast enhancement aids; C – Distinctive sports shirts; D - Bells; E - White cane; F – Exercise bicycle; G – Talking wristbands; H – Elliptical trainers

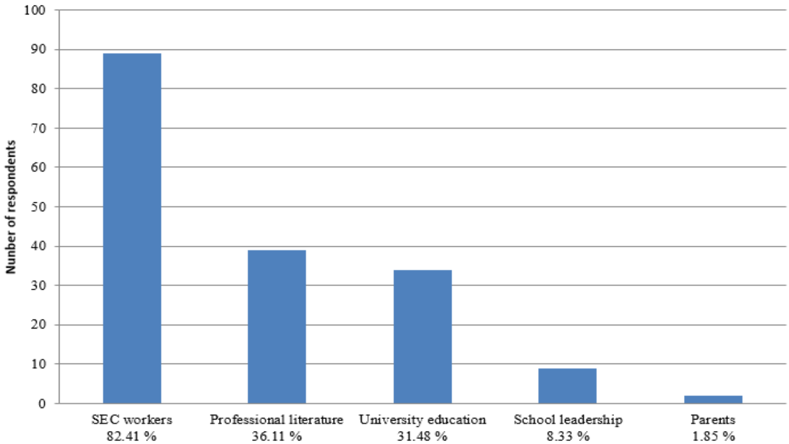

Figure 4. Sources of information on SEN of the pupil

Expert opinions on the level of involvement of pupils with VI in PE

From the results of the questionnaire for professionals – SECVI experts from the 14 regions of the CR, a sample of 57 pupils with VI was assessed. 52.96 % are sufficiently included in the group lessons of PE. In 40.88 % of cases, the level of pupil's involvement in PE is not at a satisfactory level (the pupil does not participate in teaching and has no suitable alternative activity) and 6.16 % are exempt from PE on medical advice. Teaching assistant is present during PE lessons in case of 25.90 % of pupils. 29.17 % of teachers are interested in professional consultations with experts. For significant variables, which in the monitored cases positively affect the level and quality of pupils' participation in PE, the professionals consider: pupil's own activity (18.94 %), teacher's interest (64.34 %), presence of teaching assistant (51.51 %) and support of family (33.33 %).

The professionals consider for risks: negative attitude of the pupil (33.33 %), lack of interest or negative attitude of school (15.76 %). Possibilities to participate are negatively influenced by the absence of teaching assistant (51.51 %) and, especially in case of pupils with total vision loss, the absence of specialized equipment (36.36 %). Furthermore, they mentioned inexperience of teachers with the education of pupils with VI and low level of adaptation the structure and content of education Sports courses (for instance ski training) are attended by less than 40 % of pupils with VI. Sports competitions organized by school are attended by only 28 %. In sport activities outside schools are engaged 33.34 % pupils. They are generally involved in sports clubs for children with VI, and participation in training and competitions is ensured by parents in cooperation with SECVI experts.

Discusion

Based on the above given results, it was possible to verify hypotheses. In addition, the research has revealed a number of interesting relationships which affect in practice the current situation and can become valuable guides for further development. Some of these relationships are clarified in discussion.

H1: *More than 75% of primary schools provide the included pupil with VI with an adequate level of involvement in PE*. The pupils are in 50.33 % sufficiently involved in PE lessons. Further 45.44 % of pupils do attend PE lessons, but the support measures are not applied in a satisfactory level. 3.93 % of pupils are exempt from PE lessons and do not participate in it. According to SECVI experts, 52.96 % of pupils are sufficiently engaged in the group lessons of PE. In 40.88 % of cases pupils' participation in PE is not at satisfactory level; 6.16 % of pupils are exempt from PE. On the basis of the arithmetic average of the two surveys, it can be concluded that the optimal level of education is provided by school in 51.65 % of cases. *The hypothesis was not confirmed.*

H2: *More than 75% of teachers use support measures enabling the optimal involvement of pupils with VI in PE*. The results of the survey conducted among teachers suggest that special support methods and strategies are used by 86.12 % of teachers. Adaptive sports equipment is used by 50.00 % of teachers. Special adaptations of gyms and other premises are used only by 5.56 % teachers. *The hypothesis was confirmed only in one of the three monitored categories of support measures*.

H3: *More than 75% of PE teachers, who teach a pupil with VI, are professionally competent*. A sufficient overview of pupil's documentation and knowledge of the limits and contraindications for participation in PE was showed by 75.00 % teachers. 25.00 % teachers were not sufficiently informed about the conditions and limitations of pupils. 31.48 % teachers obtained information during university studies and 7 teachers attended postgraduate education. Remaining 62.04 % build their competences for education of pupils with VI only on information from school, parents, which cannot be considered sufficient. *The hypothesis was not confirmed.*

The results of the study match in many cases to the results of other reserarches, such as the results of Janečka, & Bláha et al. (2013), which concern the amount and quality of physical activities and realized movement of persons with the VI. The authors came to the following results. The results of measuring motor competencies of pupils with sever VI differ significantly when compared to the population without VI.

The inclusion of pupils with VI to physical activities is not sufficient. The amount of physical activities is lower for all categories of VI, and is even lower for girls then for boys. In a group of children and youth, the social group actively practicing sporting activities is almost completely missing (5 – 7 times a week). Janečka, & Bláha et al. (2013) says, that youth with VI mostly lacks any leasure time physical aktivity. The tendencies mentioned above closely relate to the lack of interest in sporting activities in PE classes.

The relationship between the amount of physical activities in childhood and adulthood has been confirmed in other researches such as Abu-Omar & Ruütten, & Robine, 2004, Baumann et. al., 2009, Frömel et. al., 2006, Houwen, Hartman, &Visscher, 2009. Therefore, it is very important to support sporting activities of pupils and youth with VI and their families and to support their attendance of PE. Also, government should set control of schools following the supporting measures set to the increase of quality of inclusion of pupils with VI according to the new legislation.

We consider the assessment of risks for the full education of included pupils with VI in PE an important topic of the research. Increased attention should be given to the opinion of 75 % of professionals that the trend of number of pupils with VI, who are actively involved in teaching PE, has been declining. This assertion, however, requires further research verification. Both teachers and experts consider for the main risks of education of included pupils with VI in PE high number of pupils per class (38.89 %), lack of teaching assistants (51.51 %), lack of special assistive devices and environmental adaptations (36.11 %). Equipping schools with aids is considered insufficient also by 36.36 % of experts, especially in case of pupils with total vision loss. Another risk is *insufficient professional competence* of teachers. 9.26 % of teachers see also problem in parents' lack of interest in the participation of pupils in PE lessons. Experts consider for another risk the negative attitudes of pupils themselves (33.33 %), lack of interest of teacher or negative attitude of school (15.76 %). Another risk area is represented by *a very low level of education of teachers* who teach pupils with VI. Teachers are not sufficiently educated, which is reflected, among other things, in the low level of used support measures. *In the opinion of experts, only 29.17 % of teachers show interest in professional consultations.*

Conclusion

Education of pupils in the area of locomotor development should be regarded essential for future exercise regimen and prevention of lifestyle diseases. Pupils with VI belong to the risk group of persons with lack of movement. But majority of pupils with VI are educated inclusively; however, researches focused on the quality of PE lessons in the Czech Republic have not been implemented yet.

The results show that the level of education and provision of support measures is still unsatisfactory in a large number of schools. The reasons are pupils themselves and their parents as well as schools (interest and competences of teachers and support of school leadership). The improvement of current situation can be achieved by improving conditions for education and eliminating risks. Based on the above listed results, the following recommendations are formulated: To improve the awareness of schools about the possibilities of education and to support the motivation of teachers for their completion according to new legislation. It is also necessary to increase the number of teaching assistants for the subject of PE and/or reduce the number of pupils in PE lessons. It is also important to ensure control activity in schools concerning the provision of support measures, including aids and environmental adaptations.

The research results will become the basis for monitoring the development of quality of PE education following the new legislation - the Education Act. The basic anticipated reflection of the new legal system is an increase in the number of pupils with VI participating in mainstream schools and introduction of further support measures.

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ETHICAL PROBLEMS OF SPORT

Sekot Aleš
Faculty of Sport Studies, Masaryk University, Brno

Abstract

Sport as a social and cultural phenomenon reflects contemporary highly competitive and medially influenced society. In this context traditional accent on fair play in the field of sport is relativized in context of sports ethics as asset of norms generally accepted in the top level performance-oriented sport as means for achieving maximum success and as an expression of identification of the top level athlete who is fully devoted to the values of performance, victory and reward. Top level sport contributes, in a specific and relativized manner, to the creation of the social criteria of success, wealth and prestige. The risks of negative effects of sport are necessarily considered also in connection with the process of commercialization of sport. As the respond therefore public recognition and political support should only be given to an attractive and demanding sport fair in every respect, satisfying individual as well as collective interests of democratic society.

Key words: *sport, fair play, ethics, mass media*

Fair play in the context of contemporary top sport

Socially pathological behaviour in sport is a phenomenon which can conventionally be considered immoral and undesirable for sport and society in general because it contains elements of a dangerous, even deviant behaviour of athletes or spectators. The Czech sociological literature uses in this respect the general term "hostility" to denote expressions of hostile behaviour connected with aggression. In this context it is also useful to mention hidden forms of hostile behaviour such as hazing as a way in which one can gain control or power over another person or certain advantages, mostly in direct communication and through physical or psychological mistreatment.

In sport, such behaviour is a gross violation of the fair play principles because it is aggressive, often illegal, but tolerated and frequently deliberately supported. Also in sport the victims of hazing usually are individual with some kind of handicap. Feelings of superiority and envy may create situations when weaker players are humiliated while at the same time elitist sportsmen are fostered in the stronger or more successful ones. Hazing stands in sharp contrast to the feeling of safety, which is an indispens-able factor necessary for the integration of the fundamental rights of all participants in sport. Hazing largely undermines the physical and psychological residence particularly of young athletes. Taunting and persecution of a "rookie" by teammates or even coaches may be especially hurting and have highly negative impacts.

Hazing among adults may be latent or open and take on forms of services provided by "rookies" in the team. Verbal expressions of arrogance vis-à-vis of teammates or opponents corrupt the environment, disrupt communication and elicit undesirable influences and reactions. Aggression poses risk to the health of players and, in addition, motivates spectators to inadequate behaviour by creating negative atmosphere. It is in these situations that a club supporter loses the identity of a sport enthusiast and his or her impartiality as a spectator and becomes a brainless fanatic. Sport competition may thus become a substitute symbol of conscious or latent frustrations or aspirations. The real cases of a failure in professional or personal life is compensated with an unrestrained aggression at sports fields.

The examples of sport-related brutality, which is linked to sport sectarianism and sports crowd psychology and for which "flag bearers" as the most ardent fans are responsible, also chat practices could be used by a crowd deprived of rationality if it held a real power.

The negative tendencies in sport and thein consequences on the morals of a society are newly studied also by sports ethics which also points out the already mentioned fact that contemporary society values performance in which the stress is on quantity and that "the ethical dimension of an athlete was pushed as ideas something that cannot be measures" (Hogenová, 1997, p.105). Sports ethics is a set of norms generally accepted in the top level performance-oriented sport as means for achieving maximum success and as an expression of identification of the top level athlete who is fully devoted to the values of performance, victory and reward. In practice, so defined ethical dimension is manifested in sport on the part of the top level athlete as follows (Coakley, 2001, pp. 146–147):

- athlete is ready to sacrifice his or her non-sport interests to the imperative of success in sport and unconditionally success the demands of the competition
- priority is given to the effort to achieve quality, fame and success
- acceptance of risks and the possibility of injury, health damage and pain in the name of success in sport
- unlimited success in sport is viewed as a domain where everything is possible if an individual is willing to give it chat it takes to reach the highest goals.

In relation to the current developments in sport the following questions may be asked: Why we stop level competitiveness dominate over simple pleasure from physical activity? Why do we prefer maximum physical performance to universal development of the body? There as on probably is that the human body becomes a form of merchandise marketable on the mass culture market. The culture of sport, with its positive and negative aspects, profits and losses and the obsession with extreme performance, is deprived of the individualized alternative of physical movement which in itself is a goal, not means to achieve further goals by way of an narrowed single-purpose specialization. Sports science are thus confronted within growing urgency with the category of "sports ethics". Ethics in sports is not some isolated abstract academic concept. It reflects show sport actually works and the practices current used in it. These practices, together with the highly sophisticated sports sciences, are the requirements for and also the consequences of the achievement of maximum results "at all costs" in top level sport.

Extreme demands and goals coming along with the adoption of the principles of sport ethics require the application of extreme measures to achieve such goals: cheating, specific nutrition practices and use of prohibited stimulating preparations. In practise this in fact rise also to the never ending debates on the nature, admissibility or perspectives of doping not only on the top levels of sport. Moreover, sports science as well as practical sport will probably have to deal with gradually crystallizing phenomenon of genetic engineering which the World Anti-doping Agency (WADA) has included in its agenda with full seriousness.

As a rule, the issues of the possibilities and boundaries or extreme limits of the human body are presented through the prism of medicine and psychology, while the no less important social aspects are off the centre of attention. The Olympic motto "Faster, Higher, Stronger" contains an implicite assumption of imperfection which must always be improved: athletes have to indefatigably strive for perfection and it is their duty to try to outperform themselves. In close cooperation with coaches and sport sciences, they are required to strictly respect the principle of an effective performance-oriented model of training. This leeds to the creation of a sports-industrial complex containing a structural, institutional, ideological and cultural dimension (Maguire & Falcous, 2005, p.162), which includes the key entities such as national agencies, international corporations, non-governmental organizations and sport associations. As regards its institutional base, the retreat least free key pillars: sports medicine, practical implications of sports sciences, and regional/national top level sport centres. A science-based preparation of coaches and the application of miscellaneous informatics provided by sports science and sports medicine contribute to the achievement of "success" in sport. In this respect, there were opinions appearing particularly during the 1980's that international sport was ruled by the "iron laws of totalization", meaning that increasingly higher demands were placed on athletes in the competing dominant political systems.

The fundamental imperatives and norms of contemporary top level performance-oriented sport can also be identified in other areas where the primary value is an extreme dedication to a certain matter or goal. These are situations in which the unrelenting willingness for constant perfection of a maximum performance is accompanied with the willingness to take risks, repeatedly overcome obstacles, endure pain and hardships, and pursue tirelessly and with persistence one's dream. It is this extreme conformity to the ideas presented by contemporary top level sport as the highest goals chat makes sport such a unique and fascinating activity and such a singular form of spectacle. However, problems arise when the fundamental norms defined by sports ethics are even in the in extreme forms adopted and accepted uncritically, without asking any questions, without critical evaluation and consideration and without getting any limits, particularly the natural limits of the human body.

Probably the most extreme form of sport ethics and method of achieving success in sport is the Chinese top elite sport – a system of training of top level athletes which is based on uncompromising military practices emphasizing "strictness, discipline, intensive training and real fight exercises". They are also trained in getting rid of concerns or fears of suffering,

Difficulties, and injuries, and there is also focus on the resilience of spirit and body, skills,training and competition (Hong Wu Xiong, 2007, p. 17).

More and more often, the critics of contemporary top level sport point out that the current ideal of performance and productivity has damaged the validity and significance of the fairplay principle. In performance-oriented sport, fairplay or, in other words, conduct which respects the principles of politeness in sport, is sometimes considered a weakness, a redundant obstacle for the desired performance. What is forgotten in this context is the idea of Olympism which goes beyond fair play no only with its stress on respecting of rules but also by carrying values such as friendship, recognition of other person's uniqueness and, above all, the wide concept of sport spirit. B. Hodaň correctly states: "It is a way of thinking, not only behaviour" (Hodaň, 2000, p. 10). It is a concept that includes the aversion to cheating, doping, physical and verbal violence, inequality of chances, corruption and excessive commercialization and respect to the rules of a sport contest. In this sense, fair play means:

- respect to *rules*, which constitute the basic guidelines in each sport and any competition
- upholding the *sport spirit* that is, respecting unwritten rules, which are generally equivalent to polite behavior
- manner of thinking and code of conduct embedded in values and presented in all life situations as *life attitude* (Hodaň, 2000, p. 10).

What makes the topic of sports ethics even more interesting is the fact that participation in sport is voluntary and that participants in sport voluntarily accept the relevant rules and principles. Hence sport, as a significant socialization environment, by fostering the fair play principle should contribute in its specific way to the harmonization of interpersonal and social relations.

Top sport versus mass media

Top level sport contributes, in a specific and relativized manner, to the creation of the social criteria of *success, wealth and prestige*. In this context one can observe another impact of the interrelatedness of top level sport and the mass media: increasingly more space in sport news is given to striking headlines and loud comments regarding the commercial side of the *transfers of sport celebrities* from one sport club to another. A Czech sport enthusiast is thus immediately and accurately informed by the TV, radio and press on all the details, above all the financial and possibly other aspects, of exclusive contracts of Czech ice hockey, football, basketball or volleyball players particularly those who play abroad (the more so if they play overseas, let alone the Russian clubs which currently are most interesting commercially). Of course, the same goes for Czech coaches.

Also, the rather rare lists published particularly in the USA and Canada of the best paid and the most expensive teams and top level athletes, and most wanted in advertising. Today the most popular and most productive players in the top level basketball, ice hockey, soccer and baseball leagues had an annual income of millions of dollars. The controversial U.S. boxing star Mike Tyson earned as much as $75 million for only fifteen minutes in the ring already in the mid-1990's. Nevertheless, even with such sums he declared bankruptcy in August 2003!

These million dollar sums tell us *who, when and under what conditions* has the chance to enjoy the privileges coming along with becoming an admired and media-attracting top sport celebrity. Work as the ordinary way of creating values maybe come a ridiculed activity which is connected to values that are diametrically opposed to those of the top level sport. The optimal combination of a systematic creative work and regular recreational and relaxation-oriented sport activities is devalued to a certain degree by the antithetic emphasis on one-track sport specialization. It remains controversial to what degree certain media-adored sport idols act or may act as models of a lifelong value-based orientation on sport activities. That is, whether they may become indispensable source of motivation for a universally beneficial personal development. In a certain sense, the mass adoration of sport idols not compensated by rational and critical consideration of what sometimes is astronomical rewards for some "sport icons" may also be thought of as negative sides of sport. The thing is these rewards are not frequently linked to the sport performance proper but a regenerated from a wide range of sources, such as *advertisements and sponsorship*. The total amount of the reward thus reaches totally inadequate extreme levels, hardly justifiable morally and by common sense. It also undermines our ability to properly assess the values around us.

Adoration of top level athletes by the media is evident in the content of entertainment magazines or the entertainment supplements of many popular dailies. The lifestyle of top level sport celebrities is depicted also in interview published mostly by tabloid press reflecting directly or indirectly, intentionally or unintentionally, the diversity of the values professed by sport idols and which provides at least a partial insight in to the principles of the media-presented top level sports and sport idols. Naturally, with regard to the nature of sport models and, in this context, also value models.

The common denominator of the top level media-admired sport celebrities is *success, wealth and physical beauty*. These individuals are presented to the public as virtually unattainable model which, however, is admirable and worth following. They constitute one of the indispensable pillars of top level sport based on the achievements of success at all costs and on an incessant satisfaction of the public demand for stunning performances beyond the limits of the human organism. It is the interplay of these attributes what draws the *attention of mass media*, *sponsors and general public.* Only so defined sport may bring all the stakeholders–sponsors, marketing and advertising agencies, the media as well as athletes – such wonderful profits.

Also in sport, the consumption-oriented market culture today is linked to the growth of individualistic narcissism, obsession with authenticity and blind admiration of celebrities and obsession with consumption. From the perspective of sport celebrities and the values of a consumption-oriented society, these are in fact two sides of one coin. *Sport celebrities* frequently catch the attention of mass audience not by their performance or acts, in the first place, but by their media image which is a product of the changing world of unstable values and relativized moral principles. What is more, the desire to keep the attention of the audience and retain all the privileges of popularity leads to the use of negative promotion as well: "To be hated means to be more real and ubiquitous. To be deviant means to be unforgettable" (Blackshaw & Crabbe, 2004, p.75). The principle "to be hated is better than to be forgotten"applies to sport celebrities as well: the highly controversial boxing phenomenon Mike Tyson or the "unstable" football idol Diego Maradona definitely know better than anyone!

The increasing interconnectedness of some top level sports with mass culture point to the complexity and therefore the inconsistency of the two notable phenomena of contemporary society. Both, elite top level sport and mass culture apply the common denominator of entertainment, excitement and sensationalism. They create images of "other world" which is miles away from the real everyday world, in terms of values. Through electronic media, they attract huge masses of indirect audience and enter with great effect the domain of advertisement. In the incessant cycle of mass entertainment, sport audience becomes part of the *market mechanism* of supply and demand.

The risks of negative effects of sport are necessarily considered also in connection with the already mentioned process of *commercialization of sport*, a phenomenon that has been on the increase since the 1980's. Market mechanisms gradually affect each aspect of sport. Being massively advertised by the media, "*fitness industry"* changes the usual understanding of terms like exercise, fitness activities and health. Attendance to specialized fitness facilities is increased by the publication of expert manuals and guidebooks. Physical regeneration thus very often becomes a highly organized market-regulated process. What is worse, however, that it sometimes involves the use of health damaging and performance and muscle growth stimulating preparations and substances. *Doping* in recreational sport in the name of "body shaping" which copies the models of masculinity and femininity presented in actions films or magazines thus becomes a pressing health issue, even in comparison with the doping in top level sport (Nekola, 2000, pp. 18–21).It has also been observed that in market-oriented societies, sport participation necessarily leads to the estrangement of athletes from their own body. The *medicalization of sport*, which is related to doping, is a consequence of the situation in which the human body is seen primarily as a technical instrument or means for the production of a maximum sport performance and energy. The body no longer is a source of pleasant feelings and self-fulfilment – self-satisfaction is derived not from a simple enjoyment of physical activity but from performance and results achieved in competition (Hodaň, 2000, pp. 31–32).

This dark side of sport in contemporary society together with the phenomenon of hostility forms the separated chapter of socio-pathological behaviour in sport which stands out particularly in confrontation with the original ideals of modern Olympism.

The dynamic development and changes in sport is also driven by the increase in the significance of professional sport through mass media. Sport, physical activities and the culture of the body are used as metaphors for a wider area of social values. Hence, the advertising industry, when promoting especially non-alcoholic beverages or sport equipment, uses media-attracting sport events and plays on national sentiment.

The relationship to the broad domain of sport is also reflected in the changeable and constantly relativized values. The values, as subjective guiding principles co-determining individual's orientation in his or her activities, that are directly or indirectly associated with sport are harmony, elegance, athletic body, performance or resilience. This simplified and distorted relationship between sport activities and values thus leads to ambiguous and confusing practical consequences. A reasonable and critical assessment may generate a positive impulse and motivate an individual to start to engage in various forms of physical activities. On the other hand, masses of passive consumers of media broadcast sports are lost in an idle waiting for a positive change which, however, will never come because even sport celebrities had to pay a high price for their success in the form of hard systematic physical activity.

The progressing individualization of sport where emphasis is placed on physical fitness, the impact of government regulation of physical education and sport, and its medialisation and politicization is manifested in a number of ways. These processes are present to a different degree in individual sport disciplines, recreational forms of exercising and can also occur in connection with individual sport events. The nationalistic aspects of top level sport events could be observed in 2002 in Moscow during a public screening of matches which was accompanied by an unusually high level of vandalism. There was even a murder committed during this event. There was also another unprecedented situation: during the 2002 football championship, when the U.S. national team was eliminated from the tournament, Americans were seriously called on to boycott South Korean goods for a period proportionate to the number of goals scored by South Koreans!

From the market-regulated media sector, top level sport enters the realm of politics and stretches into the domain of consumer market. Where exactly the original mission of sport is lost on this complicated and controversial path is difficult to say. Partially this may be explained by stating that the increasing interest in spectacular sport events broadcast by the media leads to the increase in passive consumption of sport at the expense of actual participation in any leisure sport activities. It is hardly possible to acknowledge the hypothesis of a direct correlation between the volume of sport programmes broadcast by electronic media and actual participation in real sport activities. An activity as time-consuming as watching of sports may, ironically and contrary to the logic of the matter, become an obstacle to an active participation in physical activities and sport.

An important aspect of the top level sport is the need to keep meticulous account of victories and records. Ancient Olympic Games which were based in an oral culture placed emphasis on rituals, ceremonies, physical fitness and spectator participation, but kept no account of the best results or records. Conversely, the contemporary obsession with records assumes that the performance will be carefully measured, accurately recorded and published. Written culture also accents lists and dates of sport events, autobiographies of athletes, or interviews with important figures of sport. The normative principles of ethics give way to a colourful depiction of a specific sport event whit the stress on action, performance and mass attractiveness. Competition in sport does not leave much space for a strict adherence to ethical norms. Instead, significance is attributed to a system of rules and regulations determining the line between what is and what is not permitted. This creates opportunities for a subjective interpretation of the rules of a game in a particular game situation where the rules are understood differently by different parties and therefore different sanctions are expected.

Increasing professionalization of top level sport brings better training, higher performance, and stress on speed and action. So there is an increase in the importance of an offensive, aggressive playing style when each member of a team at the same time accepts more and more responsibility for the course of a match. But game rules do not define exactly the essence or spirit of a game. As a rule the goal of a game to the gain advantage over the opponent in order to achieve victory. One can also fine many examples of significant changes in rules adopted in the course of time, for instance in athletics where technical innovations of style and material

(e.g. the Fosbury flop in high jump, use of laminate poles, etc.) or training methods provide advantages where it was possible to apply such changes as effectively and quickly as possible. In most situations the following statement applies: "In ordinary situations, athletes compete under the same conditions as their rivals, however, they egocentrically look for the most favourable situation that can provide an advantage" (Gebauer, 2012, p. 1).

Undoubtedly, an extremely serious issue relating to sport ethics with implications for fair play is doping, first and foremost in top level performance-oriented sport. Drug addiction as a socio-pathological phenomenon and doping are closely related phenomena with a common historical background; however, their motivations are as a rule very different. Drugs are taken either as a sort of a painkiller and, more often, as an expression of the inability to cope with the real world from which an individual wants to escape at least for a while. Doping, that is, the use of prohibited performance stimulating preparations, especially in top level performance-oriented sport, fundamentally breaches the written as well as unofficial rules of performance is achieved in sport, which rules apply to all participants. Due to its complexity, this problem concerns not only athletes, but also their coaches, sport managers and, above all, physicians whose interest is to develop illegal performance stimulation means that would be as far ahead of the existing methods of doping detection as possible. In connection with this moral issue, questions are asked of how this matter was dealt within the past, what antidoping means and instruments are available today and what other possible forms of violating the fair play principle may be expected in future. In addition, at the university level of sport pedagogy this issue is discussed and examined marginally, as a phenomenon which definitely is contemptible but which is view as a "necessary evil" from the perspective of an effective prevention. Ethical, philosophical, psychological, sociological or economic studies, articles or debates continue to stay out of the centre of attention and become a topic only in connection with high-profile cases of doping particularly during the Olympic Games, the most prestigious bicycle races or track and field contests. What is still missing is a systematic interdisciplinary approach emphasizing generally recognized moral principles, aiming to clearly identify the sources of this vice in sport and defining a non-compromising repression policy. One thing, however, becomes clear: in the cultural domain of which the Czech Republic is part, the top level sport with all the grand events, impressive performances and extraordinary personal careers, is part of a world where social recognition is among the highest personal ambitions and where performance is the decisive criteria of success. And even in sport, where this principle works most justly, it may be a "performance at all cost", including prohibited means such as doping or unfair behaviour. This runs counter to the fairplay principle, meaning the openness of a competition under the same strict conditions and respect to the binding conditions of a tournament.

Sport as a phenomenon having the potential to offer many socially positive possibilities and opportunities is based on recognized positive values. Therefor public recognition and political support should only be given to an attractive and demanding sport fair in every respect, satisfying individual as well as collective interests and also contributing to the cultivation of population along the lines of the humanistic ideas of a democratic society.

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SOCIAL DEMOGRAPHIC FACTORS AND DOPING OF CZECH ADOLESCENTS

Slepičková Irena, Slepička Pavel
Faculty of Physical Education and Sport, Charles University, Czech Republic

Abstract

International research shows that performance enhancing drugs represent a serious problem both in competitive and leisure sports, affecting not only adults but adolescent athletes as well (Ntoumais et al., 2014; Kindlundh et al., 2008; Lucidi et al., 2008). We realized research project focused on doping in Czech adolescents (Doping in the Czech adolescents: Prevalence, correlates and experiences) granted by WADA. The main goal of the project was to bridge this gap and conduct a systematic comprehensive research on doping in the Czech adolescents involved in sports both on elite and recreational level. The project was conducted in two stages when a large scale quantitative survey was complemented by qualitative in-depth interviews. In total, we collected fully completed questionnaires from 2851 respondents (mean age 16.2 years, SD=1.84).

Here presented results concern quantitative part of the project, especially demographical data and prevalence of doping. The results show that use of doping was related to gender, age, level of sport participation, and family economic status. Doping was reported significantly more frequently by men, students of vocational schools, and students of sport schools, coming from families of more educated and physically active parents. We assessed also the attitudes of Czech adolescents toward doping (by Performance Enhancement Attitude Scale, Petroczi, & Aidman, 2009). Negative attitudes towards various aspects of doping reported 53.3-90 % of the sample. After conducting a correlation analysis (Spearman correlation coefficient) we found a significant relationship between the use of doping and gender, age, economic background of the family, level of sport participation and intention to doping use.

Key words*: doping; performance enhancing drugs; adolescence; attitudes; SES.*

Introduction

The abuse of performance-enhancing drugs (PEDs) represents a significant problem in both competitive and leisure sports. The use of PEDs violates the spirit of fair play (Ehrnborg, & Rosen, 2009) and represents a significant health concern because doping has been linked to a number of health issues, including cardiovascular, neurological, and psychiatric disorders (Kanayama, Hudson, & Pope, 2008; Maravelias et al., 2005). The World Anti-Doping Agency (2014) reports that approximately 1% of the tested samples from Olympic sports athletes and approximately 3 % of the tested samples from non-Olympic sports athletes showed positive results for doping. However, these relatively low numbers are in contrast with the results of questionnaire surveys that suggest a much higher prevalence of doping: approximately 10-15 % of competitive and recreational athletes report past or current use of doping, with some studies suggesting an even higher proportion (Ntoumais et al., 2014).

Adolescent athletes may be considered particularly vulnerable to the abuse of PEDs. From a health perspective, adolescent users are at high risk of the side effects of PEDs such as anabolic steroids (Maravelias et al., 2005; Anderson et al., 1997). A large-scale international meta-analytic study found that approximately 3 -6.5 % of boys and 1 – 2 % of girls report current or past use of anabolic steroids. Other national surveys have found that, depending on the methodology used, 2.1 %-11 % of adolescents report past or current use of PEDs (Kindlundh et al. 2001; Lucidi et al., 2008; Pedersen, & Wichstrom, 2001; Sas-Nowosielski, 2006).

Two major motivations for adolescents' use of PEDs have been discussed in the literature. First, adolescents use PEDs because they strive for physical attractiveness (Kindlundh et al., 2001), which appears to be an especially dominant motive among adolescents who participate in leisure sports (Kanayama, Hudson, & Pope, 2008; Sas-Novosielski, 2006). For example, Sas-Novosielski (2006) found that a majority of adolescent PED users predominately strived for a "better body" with the main aim of gaining muscle and losing body fat. Although more than half of the participants reported side effects of the substances (such as acne, hair loss, depression, and sexual disorders), they insisted that they would continue to use PEDs to improve their physical appearance. Second, adolescent athletes use PEDs to obtain a competitive advantage and succeed in competitive sports. It appears that a focus on victory and success in competition has become a dominant discourse even in youth sports, which has increased the incidence of problematic behavior such as cheating and doping (De Knop et al., 1996). Although adolescent athletes generally report negative attitudes toward doping, they sometimes admit that they would be willing to use PEDs to develop their professional athletic careers (Lentillon-Kaestner, & Carstairs, 2010).

However, only limited attention has been paid to doping in adolescents and related factors in the Czech context. The first larger scale quantitative study (n=554) conducted in 1995 found that about 1 % of participating adolescents admitted current or past using of doping and 14.5 % of respondents reported that they would like to try doping sometimes in the future (Slepička, Jansa, & Slepičková, 1995; Slepička, & Slepičková, 1996, 1997). Nekola (2005) found in a questionnaire survey among the members of fitness gyms (n=950) that 7.4 % of men and 1.4 % of women reported current use of anabolic steroids. A relatively large portion of the participants of the study (20.5 %) reported that they intended to use doping in the future. Pyšný (2005) reported results of a qualitative research study focusing on the motivation of adolescent members of fitness gyms to use anabolic steroids. As the main reasons for using anabolic steroids the respondents reported striving for acceptance and admiration in their peer group and feelings of insufficiency and low satisfaction with their body.

At present, research on doping in sporting youth has been almost completely missing in the Czech context and no recent data has been available which could be used in preparing anti-doping policies or designing anti-doping programs. To fulfill this gap, the project "Doping in Czech Adolescents: Prevalence, Correlates and Experiences" was granted by WADA (World Anti-doping Agency) and realized in 2014-2016. This research project explored the doping in the Czech adolescents from multiple perspectives, in quantitative as well as qualitative ways.

Aim

One of the WADA project purposes was to get relevant data on the situation in doping abuse in Czech adolescents, their attitudes toward PEDs and the influence of family background on them. We strive to answer following research questions related to questionnaire survey:

What is the prevalence of doping and other performance enhancing substances in this population?

What demographic factors are related to doping behaviour and positive attitudes toward doping in Czech adolescents?

We hypothesized that some demographical variables (gender, socioeconomic background, type of school, participation in competitive sport) are related to doping behavior in following way:

H1: Men use doping more frequently than women.

H2: Adolescents reporting more favorable socioeconomic background (including more selective schools, higher economic status and higher education of parents) use doping less frequently.

Methods

The main part of the data collection took place at high schools and elementary schools throughout the Czech Republic. The data collection at schools was facilitated by the Czech Association of School Sport Clubs. Competitive and elite adolescent athletes were contacted through various Czech sports associations. In total, 60 schools and 7 sports associations participated in the research. Based on the preferences of the schools and sports associations, the questionnaires were administered either in paper form or through identical electronic questionnaires. The data collection was anonymous, and the questionnaire was constructed in a way that prevented the identification of individual schools or respondents[3]. In total, we collected fully completed questionnaires from 2851 respondents (mean age 16.2 years, SD=1.84). Because the questionnaires were collected at the schools during school hours, the response rate was high (95%). The description of the whole sample is provided in Table 1.

Table 1. Demographic description of the respondents (in%)

Age (years)	M (SD)	16.2 (1.84)	
Gender	Male	50.7	
	Female	49.3	
Type of school	Elementary	28.9	
	Vocational	3.4	
	Secondary	51.8	
	Grammar	16.0	
Sport school	Yes	17.1	
	No	82.9	
Level of sports participation	Does not participate in sports	10.0	
	Leisure sports	53.6	
	Competitive sports	28.9	
	Elite sports	7.9	
Perceived economic situation of the family (ES)	Poor	1.5	
	Rather poor	27.5	
	Rather well-off	65.3	
	Well-off	5.9	
Education of parents*		Mother	Father
	Elementary	2.7	1.9
	Vocational	32.4	42.1
	High school	44.9	36.8
	Tertiary	20.0	19.2
Sport participation of parents*		Mother	Father
	Does not participate in sports	34.5	20.0
	Leisure sports	44.8	40.2
	Competitive sports	18.2	35.6
	Elite sports	2.5	4.1

Note: * Variable created as average of mother's and father's answers

[3] Approved by Ethics Committee of Faculty of Physical Education and Sport.

Results

Prevalence, attitudes and demographic variables

The main descriptive results focusing on the reported prevalence of doping, doping attitudes and intentions (table 2) may be summarized as follows: 227 of respondents (i.e. 8 % of the total sample of 2851) reported that they had used doping at least once to improve their sport performance. Specifically, 3.3 % reported that they had tried doping only once, 2.5 % several times, 1.1 % repeatedly, and 1.1 % regularly. The reported prevalence of doping varied between various groups of respondents. We observed significant differences between boys and girls, students of various types of schools, between respondents participating in sports on various levels, and in respondents coming from families of different economic background (table 2). These findings may be summarized as follows: 1) Boys reported the use of doping more than two times more often than girls. 2) The highest prevalence of doping was reported by students of vocational schools and the lowest prevalence of doping reported students of grammar schools, 3) students of sport schools reported significantly higher prevalence of doping than students of regular schools, 4) the highest prevalence of doping was reported by elite youth athletes followed by leisure youth athletes , 5) respondents considering themselves as well-off or rather well-off reported significantly higher prevalence of doping than respondents considering themselves as poor or rather poor.

In comparison with the respondents reporting doping use, almost twice this number reported that they were offered doping at least once (482 respondents, i.e. 16.9 % of the sample) (see table 2). Also in this group we observed similar trends as in doping users: 1) Doping was offered almost twice as often to boys than girls, 2) doping was offered more frequently to students of vocational schools and secondary schools than students of elementary schools and grammar schools, 3) doping was offered significantly more to students of sport schools than students of regular schools, 4) doping was offered most frequently to youth elite and competitive athletes, less frequently to leisure athletes.

Table 2. Prevalence of doping in various groups of respondents participating in sport (in %)

		Reported use of doping			Were offered doping at least once
Whole sample		At least once	8		16,9
		Only once	*3.3*		*8,3*
		Several times	*2.5*		*5,9*
		Repeatedly	*1.1*		*1,8*
		Regularly	*1.1*		*0,9*
Between-group differences	P	Reported use of doping (in %)		P	
Gender***	p<.001	Male	10.9	p<.001	21.6
		Female	5		12.2
Type of school ***	p<.001	Elementary	6.2	p<,001	10.9
		Vocational	12.6		24.2
		Secondary	9.7		21.5
		Grammar	4		10.8
Sport schools **	p=.002	Sport school	11,5	p<.001	23.3
		Regular school	7.3		15.6
Level of sport participation***	p<.001	Leisure	8.9	p<.001	16.9
		Competitive	7.9		20.7
		Elite	12.3		25
Economic status*	p=.032	Poor/rather poor	6.2	NS	NS
		Well-off/rather well-off	8.6		NS

Difference (chi-square test) significant on level: *** p<.001, ** p<.01, *p<.05, NS – non-significant

Apart from the reported use of doping we also assessed the attitudes of Czech adolescents toward doping (by Performance Enhancement Attitude Scale, Petroczi, Aidman, 2009) which was a part of used questionnaire. We found that the respondents reported average value 2.71 (SD=.62) on a 6-point scale in which points 1-3 indicated negative attitudes and points 4-6 indicated positive attitudes towards doping (table 3).These attitudes may be further illustrated by the results of individual items of the Performance Enhancement Attitude Scale in which negative attitudes towards various aspects of doping reported 53.3-90 % of the sample (table 3). However, it is interesting to note that these attitudes can be considered as relatively positive when compared with international studies of athletes conducted by the Performance Enhancement Attitude Scale that reported average scores ranging from 1.82 to 2.63 (Petroczi, & Aidman, 2009).

Table 3. Responses on selected items of the Performance Enhancement Attitude Scale (in %)

	Disagree	Agree
Legalizing performance enhancements would be beneficial for sports	90.0	10.0
Doping is not cheating since everyone does it	89,6	10.4
Doping is necessary to be competitive	88.0	12.0
Doping is an unavoidable part of competitive sport	83.3	16,6
Only the quality of performance should matter, not the way athletes achieve it	75.8	24.2
Athletes are pressured to take performance-enhancing drugs	62.3	37.7
Athletes often lose time due to injuries and drugs can help to make up the lost time	62.2	37.8
The risks related to doping are exaggerated	59.2	40.8
The media blows the doping issue out of proportions	55.1	44.9
Athletes who take recreational drugs, use them because they help them in sport situations	53.3	46.7

Note: Attitudes were measured on the scale: 1 (strongly disagree) – 6 (strongly agree), M=2.71, SD=.62; points 1-3 indicated negative attitudes and points 4-6 indicated positive attitudes towards doping.

Prevalence, attitudes and demographic variables – correlation analysis

After conducting a correlation analysis (Spearman correlation coefficient) (table 4) we found a significant relationship between the use of doping and gender, age, economic background of the family, level of sport participation and intention to doping use.

The users of doping were somewhat older, more probably boys than girls, participated in sports more frequently and on higher level, and reported better economic background. We observed even stronger relationship between these variables and reported offer of doping. Doping was offered more frequently to older respondents, boys, participating in sports more frequently at higher level and coming from sporting families.

Table 4. Prevalence, attitudes and demographic variables- correlations

	Use of doping	Doping offered	Positive attitudes towards doping	Estimated prevalence of doping in prof. sport	Gender	Age	Economic status	Education of parents	Sport participation of parents	Level of sport participation	Hours of sport /wk
Use of doping	-										
Doping offered	.562**	-									
Positive attitudes towards doping	.181**	.126**	-								
Estimated prevalence of doping in prof. sport	.104**	.108**	.251**	-							
Gender	.111**	.129**	NS	.166**	-						
Age	.048*	.108**	-.059**	NS	NS	-					
Economic status	.053*	NS	NS	NS	-.063**	-.075**	-				
Education of parents	NS	NS	-.047*	-.087**	-.099**	NS	.232**	-			
Sport participation of parents	NS	.087**	-.096**	-.090**	-.053**	NS	.171**	.272**	-		
Level of sport participation	.060**	.136**	-.145**	-.125**	-.182**	-.060**	.118**	.206**	.371**	-	
Hours of sport /wk	.081**	.180**	-.150**	-.098**	-.203*	NS	.118**	.195**	.353**	.668**	-

*p<,05, **p<,01, NS – non-significant

Not surprisingly, we observed a strong relationship between the use of doping and the offer of doping (r=.562); 40 % of respondents who reported that they were offered doping reported also the use of doping. The young athletes with positive attitude towards doping incline to use it (r=.181) and the doping offer (r = .126) is aimed at them. Positive attitudes towards doping makes younger athletes also rather strongly vulnerable (r=-.59). Those having positive attitudes towards doping are more tolerant and concede more prevalence of doping in professional sport (r=.0251).

The correlation analysis showed that the demographic variables were related to the attitudes toward doping in following ways: More positive attitudes were reported by younger respondents who participated in sports at a lower level (r=-.145) and less frequently (r=-.150). In comparison to the reported use of doping, there seemed to be a stronger relationship between attitudes towards doping and family variables; more negative attitudes towards doping were reported by children of parents with higher education and participating more in sports.

Conclusion

The quantitative part of the project clarified current situation in PEDs in Czech adolescents and sub-population of sporting young people. In our research, 10 % of respondents were not involved in any type of sport activity what is the result very similar to many other Czech researches. The prevalence of doping in sporting youth is more than 8 %, twice higher in boys than in girls. In elite sport, there was the higher number of athletes reported doping use (12%) but the majority of all reporting doping use are not regular PED´s abusers.

The correlation analysis showed that youth practicing sport at lower level, is more tolerant toward doping use. We did not observe a significant relationship between attitudes towards doping and gender or economic situation of the family. But attitudes towards the doping are related to the family cultural capital (education of parents and their sport participation) when higher cultural capital brings more potential to consider doping as something unacceptable within the system of adolescents´ norms and values.

Concerning doping abuse, the youth practicing sport at higher level (elite sport, sport schools) is under control of sport federations nationally as well internationally. But the recreational athletes are under any control or education what makes them very vulnerable especially when practicing sport in for-profit sport organizations. Here the question of preventive programmes aimed on this population strongly arises.

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OLYMPISM VERSUS OLYMPIC GAMES?

Strachová Milena, Sekot Aleš, Heiland Trávníková Dagmar
Masaryk University

Abstract

Sport is not only a source of experiences but in its consequences, it is a means of development of man. Sport and its institutions and important events reflect given nature and culture of society. Gradational democratisation and emancipation of society and broader mass of people during the ending of the 19th century revived the ideals of Olympism as a philosophy of life, exalting and combining in balanced whole the qualities of body, will and mind. At that time sport as an important social and cultural phenomenon had been also affected by a life style change, democratization, consume orientation in society, commercialisation, and at the time of being strongly affected via growing medialization, mutual intersection of cultures, demographic changes, globalization, etc. Original goal of the Olympic Games as the top sport organisational reflection was to place sport at the service of the harmonious development of man, with a view to encouraging the establishment of a peaceful society, concerned with the preservation of human dignity. Since last several decades the Olympic Games became the preeminent mega event reflecting the nature and problems of global society with rivalry and emulation between nations diffused or even disrupted the aspirations of Olympism. Czech Sokol Organisation considers the problem of the contemporary Olympism in its significant diversion, within its historical progress, from the original ideas and ideals. Especially the gradual one-sided orientation of Olympism towards the Olympic Games and towards the related increasing commercialisation are in the centre of critique not only sport specialists.

Key words: *Olympism; Olympic Games; sport; culture; Sokol; Sokolism*

Introduction to the topic

When discussing any problem relating to a broadly understood phenomenon of sport, respecting the fact, that sport reflects its relevant sociocultural background is essential. Culture in a traditional classical Taylor´s interpretation may be considered a whole complex which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits, acquired by man as a member of society. In short, culture represents all humanity and is specific to human groups (Mangan, 2008, p. 4).

The Olympic culture is defined as any aspect that has origins in the ideas, activities and surrounding realities. This also includes past and present, strength and weakness, successes and failures, virtues and vices (Mangan, 2008, p. 4-6). The fundamental principles, as stated in the Olympic Charter are…"*accenting Olympism as a philosophy of life, exalting and combining in balanced whole the qualities of body, will and mind"*(Horne & Whannel, 2012, p. 31). And more visible and tangible of the culture of Olympic Games.

The goal of the *Olympic Games* is to place sport at the service of the harmonious development of man, with a view to encouraging the establishment of a peaceful society, concerned with the preservation of human dignity. The practice in sport is a human right. Every individual must have the possibility of practising sport, without discrimination of any kind, and in the *Olympic spirit*, which requires mutual understanding with a spirit of friendship, solidarity and fair play.

From the perspective of an evaluation of Olympism two attitudes are evident. On the one there are „romantic idealists", celebrating the Games as a reflection of greater internationalism, peace and fraternity, treating Olympism as a quasi-religion or civil religion. On the other side there are those, who caustically criticise the Olympics, accusing organisations and individuals as being encouraged to be involved in corrupt chances, introducing potential hosts to spend great money to bid and persuade just over a hundred people to vote them, all amidst a prevailing lack of transparency (Horne & Whannel, 2012, p. 31).

Most books on the Olympics will feature accounts of the great moments and stars, repeating off-told tales of the Olympic mythology. In the context of the contemporary multiple-valued situation in the field of sport, as a great cultural and social phenomenon, it is more useful to understand the Olympic movement in its broader social and historical context. It provides multiple ways of understanding the politics, the economics and the cultures, within which the Olympic Games were forged, and within which it grew to become the *preeminent mega event.* Today much effort is put into understanding the political, economic and cultural processes that enhanced and shaped the current state of the Olympic Games, as perhaps the *most visible spectacle of modernity*, from the perspective of the postmodern world horizon. Another important fact, from the perspective of mutual relations of Olympism and the Olympic Games in the growing tendency, is that though the modern Games were intended partly as an international meeting ground, from the very beginning tensions and rivalry and emulation between nations diffused or even disrupted the aspirations of Olympism.

Olympic Games –top mega sport event

While Olympic culture, as already stated, is in the perspective of original spirituality of higher meaning, sense and genuine substance than the Games, it is reflected in the following *elements of the Games:* Opening and Closing Ceremonies, Medal Ceremonies, Sport events, Equipment, Technologies, Architecture, Environment, Hobbies (souvenirs), Educational Programmes, Olympic Values and Norms (Olympic Charter), Tourism, Gambling, Commerce: from baseball caps to burgers (Mangan, 2008, p. 120-130).

Olympic culture as an essence of Olympism lends to Olympic Games unparalleled features in the field of symbolism, artistry, ritualism, combination of nationality and universality. At the same context it is to say, sometimes from suspiciously perspective, that Games impacts on social, economic, environmental and even on relevant political surrounding and situation. And we observe growing tendency of unambiguous impacts of Games: Social, urban, economic and environmental. Anyway the Games are the largest sport festival watched via mass media throughout the world.

Since the 1920s a number of Olympic feature films have been made, The 1936 Olympic in Berlin was the first to be televised thanks to the endeavour of Nazi Germany to be presented as highly developed powerful and "peaceful" country.

Since the Olympic Games in Athens in 1896 *Olympic ceremonies* have been part of Olympic Games. Over time these ceremonies have steadily increased in number. Today the main ceremonies comprise the Torch Relay, the Lighting of the Olympic flame, the Opening ceremony, the Presentation ceremony and the Closing ceremony. They reflect both the culture of the Olympic Movement and the culture of host countries and now mostly involves set of rituals. Above all, the highly popular and by mass media globally transmitted Opening ceremony reflects, rather than Olympic culture, the effort of the host countries to be virtually presented as an innovator and introducer of fascinating show reminding rather the top world of show business than the spirit of top sportive event.

Olympic Games – historical background

The Ancient Olympic Games were held in Greece as early as 776 BC. They reflected the ancient Greeks value orientation and value education. The term "education" implied the cultivation of the whole man and could not be divided into just physical or just mental, as the mind cannot exist without the body and the body has no meaning without the mind. Therefore, the *body and mind were of equal and indispensable importance.* And only through their mutual development the potential of man was realized and acknowledged (Kissoudi, 2007). Due to continual wars, every Greek citizen had to be constantly prepared for wars of many small independent states and cities. Therefore, participation in a preparatory physical activity was regarded as a way of life for Greeks. Local conflicts often interrupted Festivals and Games.

Legal disputes and the implementation of death penalties were forbidden. The ancient Olympic Games were certainly held continuously for at least 1168 years (776 BC – AD 393). There are records of the champions at Olympia from 776BC to AD. Coroebus of Elis was the first recorded Olympic champion. Until the 77th Olympic Games (472 BC) all the contests took place on one day only; later they were spread, with perhaps some fluctuation, over four days, with a fifth day devoted to the closing-ceremony and a banquet for the champions. Women, except for the priestess Demeter, were not allowed as spectators (Mangan, 2008, p. 104-107).

Ancient athletes competed as individuals and not as a part of the team as in the modern games. The emphasis on individual athletic achievement through public competition was related to the Greek ideal of *individual excellence*. Men who attained this ideal, through their outstanding words of deeds, won permanent glory. Those who failed to measure up to this ideal realistically feared public shame and disgrace (Mangan, 2008, p. 111).

The ancient Olympic Games (OG) were inseparable from the philosophical, political, economic and social environment of ancient Greece. The continuous confrontations between the city-states of Greece made physical activities as a training forwards an integral part of a daily life. The frequent conflicts between city-states required physically fit warriors. Sport competitions were thus emphasised. Therefore, to ensure the continuity of the Olympic Games a truce was signed between those city-states at war at the time. The ancient Olympic Games, of course, were also a *religious festival* of great importance in honour of the God Zeus. Conquest of the Greeks by the Romans led to the decline of the Olympic Games. Romans in general despised Greek athletics and mostly did not support the Games. Wars, earthquake and Christianity led eventually to the complete *demise of the Games* in 394 AD.

The ancient Olympic Games lasted over twelve centuries and were *very different* from the modern Games. There were fewer events and only freemen who spoke Greek could compete. The Games were always held at Olympia, never at other sites. Games left the world an impressive cultural heritage and have had a far-reaching influence on modern world sport. With the accordance of the mutual relations of culture and sport, it was substantial for the restoration of the Olympic Games, alongside with progressive tendencies in philosophy, science, economy and politics.

Social and cultural precondition of the establishment of the Modern Olympic Games

The period from 15th to 18th centuries saw three great European Movements – the Renaissance, the Reformation and the Enlightenment. They gave rise to fundamental changes. These Movements paved the way for the development of capitalism, democracy, science and technology. Gradually *individualism and liberalism* replaced collectivism and despotism and became the essential European values. The *industrial revolution* that began in Britain in the late 18th century had a dramatic impact on society and sport. The great invention of the engine in the form of the stream train and steam ship spread new ideas, as well as sports widely and shortened distances between regions and nations. The first national and international competitions became increasingly possible to nations through the world.

The European middle classes progressively embraced the educational values of the Classical world. Mind and body became an educational concern. Modern games were systematically developed in boarding schools for boys to exhaust, control and keep the boys within the school boundaries. Academic standard were low; games-playing standard were high; games-playing was prized above scholarship. It created strong, fit and assertive schoolboys for *physical prowess but also their character and projected a sturdy self-confidence.* It attracted the attention of *Coubertin* concerned at the military humiliation of France at hands of Prussia in 1870 and impressed by successful imperialism of Britain connected also with middleclass sport. England, therefore, directly laid the foundation for the popularity of modern sport and indirectly for the revival of the Olympic Games.

The Czech Sokol sports organisation is critical to the fact that in our time the Olympic ideal is gradually focusing, within the socio-cultural, economic and political pressure, only to a form of the Olympic Games.

It was also *internalisation of sport* as a basis for dynamic drift of Olympic Games. Dynamic development of the European and American societies and above all growing involvement of the middle class into different levels of sport by 19th century, and more intensively during 20th century, had been reflected in establishing broad variety of sport clubs and associations. Sports, such as golf, gymnastics or tennis, started being popular in the industrialized world. Sport began to transcendent national boundaries and international sports **c**ompetitions and exchanges were organized in growing dynamics. Under these circumstances, international sports organizations of different sports came into being one after another. The first *international sports organization* - the Federation of International Gymnastics – was founded in 1881. In 1882 another two organizations - the International Rowing Federation and the International Skating Federation - were founded. The establishment of these organizations turned sports competitions from local events into *internationl even*ts. Towards the end of the 19^{th} century the internalisation of sport became an irreversible trend. With the increase of international sport organisations for individual sports and competitions, a large-scale comprehensive Games event, that would include more sports, was called for. Therefore, the internalisation of sport in the late 19th century paved the way for the emergence of modern Olympic Games.

The fundamental and main objective of establishing the modern Olympic Games was rooted in the intention to be a means of creation of a modern *global festival of sports.* It was not intended primarily as a historically genuine revival of the Olympic Games of a classical antiquity image. In the course of a century or more, the Games have expended both in magnitude and in popularity to meet this end. At the first modern Games 1896, for example, anyone who wished could participate. The structure of the Games gradually established and formed. In 1920 the Olympic flag was introduced at the Antwerp Games. The Olympic flame was introduced at the Amsterdam Games of 1928. Winter Games were created concurrently to the Summer Games in 1924. The Olympic Village was established in 1932 and at the same time, the duration of the Games became fixed at about two weeks. In the 1936 the established tradition of running with the Olympic Torch to light the Olympics Cauldron was created. Twenty years later the less formal parade of athletes of the Closing Ceremony was initiated in the Melbourne Games of 1956.With the increasing incidents of drug-taking and controversy over the gender identity, doping testing and female gender verification were conducted for the first time in Mexico City Games of 1968. With the development of technology, media coverage, and TV in particular, became popular and crucial from 1960. Broadcasting rights became the most important source of IOC revenue (Mangan, 2008, p. 115-125).

The 1936 Games become notorious as the „Nazi Olympics“ and in the Cold War era the Games became a symbolic battleground between capitalist and communist countries. Although the Games were intended partly as an international meeting ground, from the start the tensions and contention between nations diffused or even disrupted the aspirations of East and West. In the period between 1968 and 1984 the Games became the site of more focused symbolic *political contestation*, in which boycott became a significant political weapon. Problematic relation of the needs of festivity and security, along with the tendency for the noble aspirations of bidding cities to fade before the Games arrive, became a burning issue. The phenomenon of access and equity, in the sense of social class and the exclusion of professionals, the treatment of women, the composition and ethical standards the of International Olympic Committee (IOC), race and racism and disability sport are current affairs of contemporary Olympism. *Women* were excluded entirely from early Games and only in the 1980s the full programme of events has opened gradually to woman. At the time of being the escalation in the costs of staging the Games requires justification: Winning the Games functions to enable a whole range of giant infrastructural projects that would otherwise struggle to win support. The Games stimulate the dreams of architects and city mayors, builders and planners, leaders and entrepreneurs. „Legacy“ has become justification in the rhetoric of people and institutions being involved in the Games from various reasons and aspirations. Specific connotations for corruption, bribery or taking political advantages began to appear (Horne & Whannel, 2012). In this context is interesting to remind that it is often thought that the English journalist and author *George Orwell* condemned sport outright as simply „war minus the shooting". He certainly did not think it was a great means by which to solve problems in international relations. Whether we entirely accept his opinion regarding international sport competitions or not, we can see that Orwell was actually aware of *symbolic* politics of sport (Morgan, 126).

During their history in different level and from different reasons, the Olympic Games reflect unique features of top sport event in the field of symbolism, artistry and ritualism. And it is inevitable to remind, that such characteristic and typical feature or Games are in changing cadence specific combination of nationality and universality (Horne & Whannel, 2012).

The Future of the Olympic Games: Critical attitude

For the future of the Olympic Games it is accented from generally critical point of view to revise the following areas:

- gigantism that makes the Games difficult for future tendency to image
- security has become the central issue of all parties –bidding and organising committees of the Games, sponsors, participant and spectators
- to bring into consonance modern Olympic movement and the Olympic Games: confrontation between idealism and realism
- amateurism and professionalism
- philanthropy and commerce
- evading politics and embracing politics
- fair play an foul play
- male dominance and gender equality

The Sokol philosophy of the critical attitude to contemporary nature of Olympic in the context as a typically Czech socio-cultural phenomenon is, not only from the point of view of its main thought, essentially adherent to the Olympism idea and movement, but we also find here stimuli, resources, ways of relating and standards, which preceded modern Olympism. Sokolism is a philosophy which has been presented and stillpresents itself to us via the Czech Sokol Society (COS). The Sokol idea is based on thegeneral national profile of citizens, their culture, identity, quality and ideals. Sokol is a way to perceive and comprehend the world and focuses on being human in the ontological sense ofthe word.

The problem of responsibility arises, as it does with the bringing into reality of everygreat idea. If Sokol is responsible for the *national moral profile of citizens*, then Olympism isresponsible for the *nations as a complex*. Responsibility in the sense of a whole can beexpressed using the Greek term *Areté*. Basically the goal is, through training the human body,to achieve a state of harmony with the human soul. To be wholly responsible in the sense ofself-overlapping to achieve a whole. Old Greek expressed this harmony as Kalokagathia.Sokol and Olympism are, in principle, forms of Areté. That is why we are concerned with thatwhole and fill it with such a content as to return it to its original position of esteem andrespect - Areté.

For the critical perspective of sports scientists is mostly concerned with crucial problems as follows (Mangan, 2008, p. 130-132):

1. Increasing involvement of government and corporations the IOC autonomy is under increasing threat.
2. Corruption of Olympic officials has led to public loss of confidence in the Movement.
3. Drug-taking (doping) athletes threaten the future of the Movement.
4. It is taken in doubt that sportsmen are meant to be the delegates of Olympic ideas and the Games would become a great event that spreads the Olympic mission around the world.

Also from the point of *Sokolism* the problem of the contemporary Olympism is seen in its significant diversion, within its historical progress, from the original ideas and ideals. Especially the gradual one-sided orientation of Olympism towards the Olympic Games and towards the related increasing commercialisation. Olympic Games, as a visible ideology carriers of the Olympism have gradually become Olympic Games of the economists, businessmen, politicians, managers or specific lobbying pressure groups. Olympic values and norms are also manifested symbolically in the Olympic motto „Citus, Altius, Fortius“, now universally accepted to mean „Swifter, Higher, Stronger”. And it was this very imperative that has become the strongest impulse of preparation and participation at the Olympic Games. Therefore, the original idea of participation in the Olympics is gone, and attitudes as *"at any cost"* or by means of prohibited doping substances become more and more frequent. The doping "chemistry", together with the doping tests, corruption scandals and abuse of sports medicine are essential duties of the Olympic authorities nowadays, similarly to the situation in peak performance sport, in general. The Olympic Games thus become a focal point interest of individuals and groups who do not relate to the Olympic ethos (areté, kalokagathia – individual responsibility for the whole, harmony of physical and mental development) at all. The function and mission of sport itself are changing.

Sokolism considers sport and physical activity not substitutable, but additional activity of a versatile development of man. For Olympism sport is performance the means which is crucial for potential victory (Nešpor, 2003). These days the Olympic ideal is gradually focusing, within the socio-cultural, economic and political pressure, only to a form of the Olympic Games. The Olympic Games are thus becoming a primarily competitive event of not only the sportsmen themselves, but also of a best possible medal placement of the individual participating states. Whereas in the context of Sokolism by Miroslav Tyrš, sport was primarily a goal towards achieving a broadly developed individual and consequently, towards a harmonic society, within the top performance Olympic competitions, sport is mostly a means for achieving victory, performance, records, prestige, fame and fortune.

Fundamental Problem of Olympism and Olympic Games: Changes of sport

Since the time of Pierre de Coubertin many things have changed and sport has undergone a significant progress. Its core is, however, basically the same. Sport is not only a source of experiences but in its consequences, it is a means of development of man. Physical training is important as an active aspect of increasing performance and improvement of man. Processes of globalization do interfere with the field of sport, naturally. External conditions, under which the values of sport shall be implemented today, are more and more complicated. Essential changes relate to sport and its organisation, contents, values, functions and conditions. Sport is also affected by a life style change, democratization, consume orientation in society, commercialisation, medialization, mutual intersection of cultures, demographic changes, globalization, etc. In most of the cases these influences do not affect just sport, but it is sport, where they find an active implementation. Social progress determinates sport significantly. The sportsmen themselves may thus affect sport and its aspects only to a limited extent. Sport is also perceived and affected by politics, economics and media sphere. Form of sport is determined by public demand motivated by various tasks and goals. However, it often affects the core of sport and influences its original mission. It seems that several impacts of the past decades become stronger and we may often hear voices emphasising that the substance of sport is in danger: *fair-play violation, doping, violence in sport* and its surroundings, *nationalism, extensive commercialisation, corruption, cheap medialization, cult of stars, etc.* These negative aspects are often associated with sport. In most of the cases, the factors endangering sport are not sport-specific, but they are considered social aspects that found positive attack conditions particularly in sport. Therefore, it is sometimes difficult to implement the original sport vision while organizing and promoting sport. We may even state that sport is, from a specific point of view, impeached to such as extent, that aversion towards sport appear in public. Sportsmen often represent models, especially for young generation. If the economic prestige is emphasised above all, one may not wonder that behaviour of those models is imitated, regardless the fact, whether it is a socially acceptable behaviour or not. Furthermore, the publicly presented model of a sports behaviour often creates a specific moral norm of human action, not only in sport (Payne, 2006).

Present-day sport is *not the same sport* as Pierre de Coubertin defined. It has changed, it has become a world-wide phenomenon and universal "*model of culture*" to a certain extent. Not only for this reason is it obvious that all the traditional values of Olympic sport could have stayed unchanged. However, some of them are still valid and shall stay valid. Respecting dignity, reputation of man and respecting his personality is the most considerable aspect. In sport we shall always see a sports activity in coherence. And it is necessary to conclude: In the contemporary *sedentary society* loosing successively necessity of intensive physical activity in most professions, in households and in individual ways of transportation, the regular leisure and wellness sportive activity of mass of active people of few individuals competing for medals, victory, stardom, records and money (Sekot, 2015).

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VIEWS OF STUDENTS ON THE STUDENT EVALUATION OF SPORTS TEACHING

Valkounová Eva, Jůva Vladimír
Masaryk University, Faculty of Sports Studies, Czech Republic

Abstract

As a result of stricter requirements for quality of university teaching, the importance of student evaluation of teaching (SET) increases. The paper is focused on SET at the Faculty of Sports Studies Masaryk University (FSpS MU). It deals with specific aspects of the university sports teaching and the related requirements of the SET. The aim of the empirical qualitative research was to find out the views on the SET of selected FSpS MU students. The focus group research method was used. The research sample consisted of four purposively selected respondents, two from the doctorate study and two from the postgraduate master studies. The results of the survey show that the decreasing number of completed SET is mainly related to the reluctance of students to spend their free time filling in the SET, feeling unnecessary repetition of SET and inadequate feedback from teachers. Students who complete a SET are likely to be especially those who are either very satisfied or very dissatisfied with the teaching. On the basis of the research carried out, we present suggestions that can contribute to a more efficient use of student evaluation of university sports teaching.

Key words: *quality of teaching, university sports teaching, feedback, student evaluation of teaching (SET)*

Introduction

Particularly in connection with the requirements for improving the quality of tertiary education and extensive discussions on the concept of Czech university education, the importance of **student evaluation of teaching (SET)** has also grown in recent years as a standard area of internal and external evaluation of university teaching. The aim of the paper is to highlight the importance of the university SET, especially the specificity of the evaluation of practical university sport teaching. According to the *Pedagogical Dictionary,* student evaluation of teaching is defined as "one of the methods of evaluation of the quality of university teaching, sometimes secondary teaching" (Průcha, Walterová, & Mareš, 2009, p. 292). Observers and evaluators in SET are mostly full-time students, less often combined students of bachelor, unstructured (long) master, follow-up master and doctoral study programs and students of lifelong learning programmes. They can also be graduates of all the above-mentioned forms of study.

The subject of SET is most frequently evaluation of the teaching activity of a particular teacher and evaluation of a particular subject, which can be taught by one or more experts. The basic levels of SET are mainly focused on individual teachers and subjects, but also on entire departments, faculties and universities. „However, the subject of evaluation may also include study plans, overall satisfaction with the study program or field, infrastructure and services, academic self-government, etc.“ (Mareš, Soukup, & Tomášek, 2013, p. 1).

The SET is currently an important evaluation tool for ensuring and improving the quality of tertiary education. Wang et al. (2008) point to the need to involve university students in the evaluation of university sport teaching, particularly in the context of internationalization of tertiary education. The importance of SET in Czech tercial education has been increasing in recent years, especially in terms of emphasizing quality of teaching versus quantity. This requirement was highlighted in the Czech White Paper on Tertiary Education (Matějů et al., 2009) as one of the main priorities of the evaluation of tertiary education quality. In this document, among others, the requirement for standardized evaluation of the quality of teaching, both by students and other objective indicators was emphasised (ibid., p. 20). The SET has an importance for both the evaluating students and the evaluated university teacher or the institution as a whole. Due to the thematic focus of our paper, we will look at the SET from the students´ point of view.

For evaluating students SET is especially important as a platform where they can express their opinion regarding teaching, participate in the evaluation of the faculty, or participate in the teaching process (Šmelová, 2002). It also contributes to the development of student diagnostic competences when learning to objectively evaluate the educational process. This aspect is important not only for future teachers of physical education, but also for other sports professions (e.g. coaches, referees, etc.). Mareš (2006) notes another important feature of SET, which is to provide feedback to students of lower grades. These students have the opportunity to obtain information within the SET about „...which lessons and courses are good, worth to enroll, and which are a waste of time.“ (Mareš, 2006, p. 10).

The use of SET evolved spontaneously at the level of individual faculties since the 1990´s. Gradually, however, Czech universities tried to unify and create university-wide evaluation tools, for example, Masaryk University (MU) has long been using the SET in the form of electronic **Subject Surveys placed in the MU Information System** (hereinafter the Subject Survey in IS MU). As part of the unification of evaluation tools, discussion is being developed at the same time if a single form of

SET is appropriate for different study disciplines or whether it is more effective to modify its evaluation tools for specific faculties, study fields, groups of subjects, etc. due to the differences among studied disciplines.

The study of physical education and sport has its specific features not only in terms of the nature of sports teaching, but also from the point of view of cultures of sports faculties and their students. The practical nature of teaching is not only typical of sports universities, but also of general physical education intended for students of „non-sports“ disciplines. As Guinn & Vern (2006) point out, the specificities of university sport teaching are also reflected in the SET. In their research, they compared the results of SET from 14 sports and health-oriented faculties with 25 economics universities. The research results highlighted the need to modify the evaluation tools for university students with regard to their field of study. SET in the study of physical education and sport has been dealt with by Mohr, Sibley, & Townsend (2012) who have found out that student‘s evaluation of sports teaching is subjectively influenced by the learner‘s self-assessment as part of his / her progress in relation to the set learning objective. Another study, focusing on the specific features of sports teaching, was conducted in 125 US departments of physical education. Its aim was to evaluate the quality of sports teaching (Yu, 2001). Research has confirmed that SET is one of the main components of evaluation sports teaching at the universities in study.

Teaching at sports universities in most cases takes the form of practical lessons that take place in gymnasiums, but also in other sports facilities or in the wild. It often takes the form of longer intensive sessions of instruction, eventually multi-day courses and professional practices. The specificity of student appraisal of practical sports lessons is dealt with by few authors. E.g. Hoffmann (2006) draws attention to the fact that there are a number of suitable tools for the students‘ evaluation of the theoretical university teaching, but for practical sports lessons, no such evaluation tools have been tested and statistically verified. For this purpose, the FEFA ("Frageboden zur Evaluation der fachpraktischen Ausbildung") questionnaire was created. A similar tool for SET was created and verified by Pavlov (2011). It was, however, an instrument specifically focused on practicing outdoor sports lessons.

Student evaluation tools for teaching at FSpS MU

The use of SET with a focus on the specific features of sporting instruction is particularly important for university departments providing this teaching. As we have already mentioned, for the evaluation of teaching at MU, the Subject Survey in IS MU evaluation tool has long been used within the SET. This tool was used in the autumn semester 2012 and in the spring semester 2013 for evaluation of the teaching of innovated subjects at FSpS MU as part of the IMPACT project[4]. The Subject Survey in IS MU consisted of 7 evaluation criteria with an eleven-step scale[5]. The individual evaluation criteria focused on the following areas:

1. Subject interest (not interesting at all … is very interesting)
2. The profitability of the subject (not very beneficial … is very benefical)
3. Difficulty of content (very easy … very difficult)
4. Difficulty in preparation (very easy … very difficult)
5. Availability of study materials (very poorly available … very well available)
6. How the teacher teaches (poor … excellent)
7. The teacher as an expert (not an expert … an expert).

Based on the experience gained from the Subject Survey in IS MU, we have confirmed that this relatively brief, full-university form of SET is of a general nature, focuses rather on partial aspects of teaching and provides only input data on the quality of teaching. Within sports teaching and the established evaluation objectives of the IMPACT project, it does not allow deeper feedback and does not give specific information about the relationship to the field studied. For this reason, we have proceeded to develop our own evaluation tools[6]. Mareš et al. (2013) draw attention to the fact that when creating the SET tool, it is necessary to determine to whom the survey results will be primarily designated and what the recipient will need. The main objective in the preparation of new evaluation tools at FSpS MU was to provide detailed feedback to the teachers who participated in the innovations of individual subjects and their teaching. In line with the general recommendations (Mareš, 2006, p. 9) we „emphasize more detailed structured teaching characteristics, for a more detailed, more fragmented view." We have prepared two new SET tools - **Student Subject Evaluation** and **Student Practice Evaluation**. These evaluation tools focused in more detail on the specific features of sports teaching and aspects related to the innovation of subjects at FSpS MU. The tools were commented in the framework of internal and external evaluation, addressed by colleagues from FSpS MU and subsequently from FTVS UK Prague and FTK UP Olomouc. Furthermore, they were tested by selected students of FSpS MU. After all comments have been incorporated, the evaluation tools have been converted to an electronic version in the IS MU environment.

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[4] The IMPACT project (Innovations and Modernization of Study Departments of the FSpS MU) took place at the FSpS MU within the framework of the Operational Program Education for Competitiveness in 2012-2014. The aim of the project was to improve and modernize education at the FSpS MU.

[5] In 2015 there was a modification of the Subject Survey in IS MU. It now consists of eight closed and one open question.

[6] In the development of the evaluation tools as part of the IMPACT project MUDr. Petr Ježek and PhDr. Šárka Maleňáková, Ph.D. also participated.

The **Student Subject Evaluation** consists of 35 closed questions (response quotes with five-step scale) and 7 open questions. The **Student Practice Evaluation** consists of 25 closed questions (response quotes with five-step scale) and 6 open questions. During the creation of both evaluation tools and for the purposes of their evaluation, we divided the questions according to the thematic focus into individual subgroups. The importance of SET and newly developed evaluation tools for teaching at FSpS MU are discussed in more detail in paper from Jůva & Valkounová (2017).

Methodology

In connection with the IMPACT empirical survey of SET, a research study was held in the spring of 2015 to identify problems that may be associated with SET at FSpS MU students. Given this goal, which focuses on identifying individual views and attitudes to a specific problem, we chose a qualitative approach. Data collection was conducted using the focus group (see Stewart & Shamdasani, 1990; Šebek & Hoffmann, 2010). The research sample consisted of four respondents. Two undergraduate students and two doctoral students, always one male and one female. The main criteria for the purposive selection of respondents were as follows:

1. active („good“) student of FSpS MU,
2. long-term personal experience with SET and
3. willingness to participate in the research.

All respondents were briefly introduced to the empirical survey, agreed to participate in this study, agreed to recording of the discussion and using anonymous data. The main focus group topic was the SET-related problems associated with the ever-decreasing return of completed SETs. All the respondents had experience of both the SET within the subject survey in IS MU and the newly developed evaluation tools at FSpS MU (Student subject evaluation and Student practice evaluation). To maintain the ethical standpoint of research, we will not name students or the leader of focus group. It was an FSpS MU employee. The focus group lasted an hour and a half. The focus group was recorded on the recorder and subsequently transcribed. Empirical data were acquired by transcribing answers by open coding technique. Based on the categories created from quantitative data within the broader IMPACT project (see above), the focus group categories were narrowed down upon further processing only to SET problems in selected FSpS MU students. These categories are student awareness of SET, SET volunteerism, SET anonymity, reasons for (not) using of SET, importance of SET, SET problems and suggestions for SET.

Results

In the first category, regarding **student awareness of SET**, we noticed that students during their studies encountered different forms of SET. These were Subject Survey in IS MU and the newly created evaluation tools Student Subject Evaluation and Student Practice Evaluation. Information about the possibility of filling the evaluation tool was found by students to be very good thanks to IS MU.

In the second category**,** regarding **SET volunteerism**, students appreciated that evaluating of the teaching is not compulsory. But this leads to the fact, that only a part of the students express themselves in the SET, and (students emphasize) „this is meaningful“. In the discussion, there was also the opposite view that „I do not see why it should not be mandatory...“. Respondents are aware that the rating would have „greater value“ for university. Also, there was a counterargument, based on personal experience with completing a SET at another universities, where the assessment required that „students just mindlessly tick the check boxes.“

For **SET anonymity** category, respondents pointed out two tendencies. On the one hand, there is a legitimate fear of revealing anonymity, since students of SET are signing through IS MU under their identification data. This means that there is a real risk that a particular student can be identified behind the completed evaluation. At the same time, students say that „anonymity may slip to deal with the teacher...“ and that „it is criticism but without indication what to change.“ In this context, there was an opinion that students are partners of the university and therefore anonymity at SET is not in place. It should not be „dealing with teacher ...“ but the objective should be constructive criticism. This critique should belong to the student‘s skills. „I would therefore like more signed criticism...“. „The signed evaluation would be more objective.“

In the fourth category, the **reasons for (not) using the SET**, students do not feel the need to comment on each subject. Filling out SET for them represents „...the possibility of expressing what they feel“, „..the best opportunity to express one‘s own opinion“. Students rather fill the SET in a situation when they are unhappy and have specific criticisms – „...they took it as a chance to express dissatisfaction...“, „... more motivated are those who are rather dissatisfied, but it can be an advantage.“ All respondents were predominantly convinced that satisfied students did not need the evaluation tools to fill in. The specific reason for the non-fulfillment of the SET is that it is time-consuming: „When I saw how many courses I have enrolled, I opened it, filled in one or two, but then I did not even save it... I estimated that it would take about an hour.“ At this point, the subjects fully agreed and stated that the time requirement for filling the SET can increase in some semesters up to 2.5 hours.

In the fifth category, the **importance of SET**, subjects consider SET as a helpful step of their alma mater. The importance of SET from students‘ point of view is related to their belief that they can „believe that they will influence something.“ Respondents also agreed that by filling in the SET „...is created a relationship between student and teacher“, whether positive or negative. That is very important, according to the respondents, as there is no relationship between teacher and student during teaching. Respondents also emphasized the importance of SET for the evaluators themselves: „The student learns to make his own opinion, to be able to defend it...“.

From the point of view of the sixth category, the **SET problems**, respondents feel that the SET results do not work very well, if at all. They are not sure whether the teacher will read the review. The problem is also seen in the fact that feedback to the results is provided by IS MU, but it takes an effort to get to this data... „lots of clicks on your PC“, „more reviews must be completed“. In addition, „...the student will only get to the average...“. Another major issue is the objectivity of the evaluation. „The subject that students enjoy, will probably be better rated. Vague theoretical subject will have worse grades, even if the teacher is the best.“ The objectivity of the evaluation is also related to the dealing with teacher. As a significant factor, which also affects the objectivity of SET, the subjects consider the climate of the study group.

In the last category, **suggestions for SET**, respondents recommend to add a justification for their choice for each scaled answer in the form of an open answer, because of reducing the possibility that the SET will be completed in rush. The open items in the evaluation, according to the respondents, will probably show better who the rating „... filled in more objectively and who wants just get it done...“. Furthermore, there was a suggestion that a student would be able to select only a limited number of subjects, but would then be responsible for the quality of the criticism. The question that remains unanswered is the deadline for filling in the SET. It is offered in the exam period, but students have „other things to worry about“. A later term would have the advantage that „...a person will cool down...“, but at the same time, he will probably forget the negative and positive aspects of the evaluated teaching.

Discussion

As pointed out by the studies with similar focus (e.g. Švaříček et al., 2016), methodical recommendations (e.g. Ježek & Mareš, 2012) as well as the long-term experience with filling in the Subject Surveys in IS MU, the biggest problem of SET is the return of student evaluation (see more details Jůva & Valkounová, 2017). Decreasing number of filled-in SETs is probably related to the fact that students already know this evaluation method from the previous semesters and are unwilling to spend their free time filling them in. Students may also be dissuaded by the fact that they do not receive prompt and specific feedback from the teacher. This situation is partly related to the primary objective of new evaluation tools, namely to provide feedback to teachers who have inovated their subjects. The reason for the low SET return can be, as suggested by the qualitative research study, that evaluations are typically used by dissatisfied students and that the evaluation is voluntary. The declared anonymity of the student evaluations should positively influence the return rate. However, a qualitative research study has suggested that students (and probably older graduates whose representatives were elected by the respondents) legitimately feel themselves part of the academic community and would therefore welcome a non-anonymous form of SET that would, in their opinion, be more specific and would better fulfill its function.

Therefore, one of the main issues is how to better motivate students to participate in a regular SET. On the basis of the feedback received from the respondents, we believe that the students could be motivated by a higher feedback on their evaluation from a particular teacher of the subject and especially easier accessibility of the SET results. Another motivational option could be the student‘s own choice to fill in only the subjects to which they feel the need to express themselves. Higher SET return can be also achieved by the deeper awareness of students that by completing SET they not only contribute to improving the quality of their faculty education but also develop their own diagnostic competence and learn the necessary constructive critique. Attendance at SET helps students to develop their own professional competencies, that is future physical education teachers, sports coaches, referees or other sports professionals.

University sports teaching has a number of specific features. Therefore, we believe that in parallel with the SET general tools (mostly within the whole of the given university), there also should be developed and used appropriately specific, branch-specific instruments, in our case oriented to tertiary sports education, which in their character (e.g. frequent block and practically focused teaching) creates a number of options for appropriate and informal use of SET.

Conclusion

Student evaluation of teaching is one of the effective tools for improving the quality of tertiary education. Its importance lies not only in providing feedback (to teacher, department, faculty, ...), but - and this is a very important aspect of university sport education - also in developing the ability to diagnose and evaluate, in the area of key competences of future trainers, physical education teachers, referees and other sports professions.

In our paper we have pointed out the importance of SET as part of evaluation processes within specific features of the university sports teaching. On the basis of a qualitative research study, we found out the opinions of selected FSpS MU students at SET, and we introduced some suggestions that could motivate students to fill in the SET more regularly, thus contributing not only to a more effective evaluation of university sports teaching but also to promoting their own professional competencies.

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PHYSICAL ACTIVITY OF SPECIAL OLYMPIANS DURING A SUMMER OUTDOOR CAMP

Válková Hana[1], Králíková Jitka[1], Dygrýn Jan[2]
[1]Faculty of Sport Studies, Masaryk University Brno, Czech Republic
[2] Faculty of Physical Culture, Palacký University Olomouc, Czech Republic

Abstract

The goals of the Special Olympics Healthy Athletes program is to assess the level of physical activities of individuals with mental disability. Studies indicate that people with a mental disability are less engaged in physical activity than their peers. The published data was mainly collected from oral feedback. The objective of this study was to assess physical loading of persons with intellectual disability, really to assess the physical activity of Special Olympians during 6 days summer outdoor camp using an accelerometer and to analyze their level of physical activity in relation to gender and age cohort of the camp participants. Forty-seven participants (21 males, 26 females) at the age from 14 to 52 wore a GT3X ActiGraph to record their physical activity levels for 6 days during the outdoor camp approx. from 7 a.m. to 10 p.m. Their activity was recorded every day by trained volunteers (camp leaders). The content of activities was based on the principle of Eunice Kennedy Shriver camp and consisted from walking, hiking, easy team outdoor plays, table tennis, cycling. Participants realized the exercises in co-educated groups (males and females together) with respect to their age, physical and intellectual capacity. The physical activity levels of participants were higher than published guidelines.

Average items: males 4,943 steps per day, 33.6 min of moderate activity/day; females 3,727 steps per day, 27.1 min of moderate activity/day. Our sample was 1.7 times more active than an ordinary population. These findings disagree with the previous published results even if we respect that they were assessed during an outdoor physical activity camp. In spite of the fact the guided program was similar for both genders: the males were more active than females, which is relevant with findings in the general population. The analyses of the achievements of the age cohort older than 35 years showed the daily results: 13 males – 4.056 steps and 39.1 min of moderate activity; 13 females – 2.881 steps and 16.5 min of moderate activity. Regarding the level of physical activity we can conclude the persons with mental disability (Special Olympians) can realize a higher level of physical activities under a guided program. The local Special Olympics initiatives are beneficial for people with mental disability. The project should be repeated with the same participants during their regular week and in relations to their BMI, fitness variables, etc.

Key words: *Intellectual Disability, Eunice Kennedy-Shriver Camp, Steps, ActiGraph*

Introduction

International government agencies and research groups have published guidelines on the amount of physical activity (PA) people should participate in. They state that people should participate in at least 30 minutes PA of moderate intensity each day. In addition, it is recommended that performing 20 minutes of continuous vigorous activity at least 3 days a week can improve cardiovascular health (U. S. Department of Health and Human Services, 2003; U. S. Department of Health and Human Services, 2009). The PA behavior of adults with a mental disability, consistent with the U.S. Surgeon General's recommendation, is 30 minutes of moderate intensity of PA five or more days per week (Murphy, 2009). More specifically, moderate activity includes large muscle group activities, which is equivalent to brisk walking, dancing and yard work; with vigorous activity including repetitive large muscle activity at an intensity equal to 70% of the age-predicted maximum heart rate (e.g. jogging and lap swimming).

There are findings which suggest that people with disabilities are less active than the general population (Longmuir & Bar-Or, 2000). Related to a categorical approach (Sherrill, 2003) the presented research is oriented towards adults with mental disability.

Definition "mental disability" by the World Health Organization (WHO, 2003), is referred as substantial limitations in present functioning. It is characterized by significantly sub-average intellectual functioning, existing concurrently with related limitations in two or more applicable adaptive skill areas: communication, self-care, home-living, social skills, community use, self-direction, health and safety, functional academics, leisure and work. The definition suggests that disability is not only apparent in the cognitive and intellectual domain, but transcends a person's whole personality (Válková, 2007). Sherrill (2003) stressed the ideas of Cratty (1972) and Kephard (1911-1973) that movement is the basis for intellectual development. They discussed a lot of motor features relevant to the maturation of the central nervous system (CNS) or "brain maturation", such as motor exploration, reflex and postural adjustment, balance, laterality and directionality and body image. The issues of mental disability, PA and other associated problems like congenital heart defects, muscle hypo-tonicity, joint hypermobility, low cardiovascular fitness and decreased muscle strength, diabetes are well documented (Barnhart & Connolly, 2007; Draheim, 2006; Draheim, Williams & McCubbin, 2002; Dykens & Cohen, 1996; Wright & Cowden, 1986). Taking this into consideration, participation in regular PA by people with a mental disability is essential for their health; however – question is – what is reality. Physical inactivity of persons with a mental disability in relation to fitness, the risk to health and obesity were examined by Fernhall et al. (1996), Onywadume (2008), Robertson et al. (2000) and Yamaki (2005).

Studies indicate that people with a mental disability are less engaged in PA, are more sedentary and are less likely to be physically fit than their peers (Foley et al., 2008; Frey, Stanish & Temple, 2008; Johnson, 2009; Peterson, Janz & Lowe, 2008; Temple, Frey & Stanish, 2006; Tudor-Locke, Washington & Hart, 2009). Authors reported that 56% of people with disabilities do not engage in any leisure time activity, compared to 36% of people without disabilities.

Less than 20% of adults with disabilities engage in vigorous activities that promote fitness or muscular strength (U.S. Department of Health and Human Services, 2009). Stanish, Temple and Frey (2006) found that the major sources of PA for adults with a mental disability were walking and cycling, housework, gardening, dancing and the Special Olympics program. Walking was by far the most prevalent form of PA, but studies suggest the intensity may not be sufficient to meet the minimum recommendations to achieve health benefits (Stanish, Temple & Frey, 2006; Temple, Frey & Stanish 2006). Findings from research carried out on Czech Special Olympians documented that both adolescent males and females spent approximately 7.5% or 53 minutes of their day partaking in moderate physical activity (Válková, 2007). Meanwhile, in a pilot study by Shields, Dodd and Abblitt (2009), almost 58% of children with a mental disability, particularly with Down syndrome, did not perform the recommended amount of PA to maintain good health, and none performed the recommended level of continuous vigorous PA to enhance cardiovascular fitness. A significant inverse association was found between the amount of activity undertaken and age, with older children taking part in less activity. Nevertheless, people with a mental disability have a lower VO_2 peak than not be appropriate for the mentally disabled (Robertson, 2000).

Pitteti and co-authors (1989) assessed the fitness of adult Special Olympic participants. Later Pitteti at all (2010) compared the advantages and disadvantages between using a classic pedometer and an accelerometer in children aged 6-10. A pedometer is used for taking measurements when walking, whereas an accelerometer (ActiGraph) is used for other activities besides walking. Children with a mental disability engage in different types of PA, not only walking. Until recently, there have been no studies that validate the use of an accelerometer for people with a mental disability during an exercise intervention program. As the academic researchers probably do not believe the assessment of individuals with ActiGraph (accelerometer) can be realized. Only several studies with using ActiGraph are published (Mokrosova, 2013; Murphy, 2009; Pitteti, 2010; Valanou, Bamia, & Trichopoulou, 2006; Válková, Qu, Chmelík, 2014; Wouters, Hilgenkamp & Evenhuis, 2017).

Therefore, it is necessary to find out if a well-planned exercise program, like the Special Olympic Local/National Program which can help to enhance the fitness of people with a mental disability, and help them establish a good daily routine of the recommended amount of PA. In the meantime, it can assist health professionals involved in disease prevention to develop strategies that will enhance the participation in physical activities of people with a mental disability. Special Olympics Healthy Athlete program and Healthy Community supports healthy living style as so as research on this field (Special Olympics 2004, 2010).

The aim

The intention of this study was to verify that persons with ID are able to achieve the recommended values of physical activity as a common population. In reality the objective of the project was to assess the physical activity of Special Olympians during full six days of summer outdoor camp using a GT3X ActiGraph (2010) and to analyze their level of physical activity in relation to gender and age cohort.

Method

The participants (86) of the summer outdoor SO camp in Jeseníky mountains were offered to be included in the Healthy Athlete Program survey. The survey was attended voluntarily by 47 people (21 males, 26 females), aged between 14 to 52 years. Nobody was touched with multiply disability, two boys with Down Syndrom and three girls, both in younger age cohort were included among them. All participants have entered in a moderate level of intellectual disability and were familiar with Special Olympics. Ethical consensus was secured by the Czech Special Olympics regulation that all registered in the SO have this signed agreement.

Data collection and processing: after explanation and motivation participants wore a GT3X ActiGraph instrument alongside the belt to record their physical activity levels for 6 days from approx. 7 o´clock a.m. to 10 o´clock p.m. ActiGraph was not used during sleeping time and contact with water (hygiene, activities in the swimming pool). Every morning their daily activities were recorded by trained volunteers (leaders of camp divisions). The content of activities was based on the principle of E. K. Shriver camp (which is common for Czech outdoor camps, too) and consisted of walking, hiking, easy team outdoor/indoor games, table tennis, cycling, disco dancing. It was lucky that the weather was good in that week that allowed PA in the open air.

Participants realized the exercises in co-educated groups (males and females together) with respect to their age, physical and intellectual capacity. Although the data from ActiGraph provides many analytical capabilities, we only chose: activities in minutes per day (MPD) sedentary, MPD light, MPD moderate, MPD vigorous, steps per day. Data in minutes was processed by descriptive statistics (arithmetic mean, percentages), separately by intensity of PA (mild, moderate, vigorous), then minutes combined moderate and vigorous together. In addition, values for the whole group and separately for males and females were processed (Table 1). The data was also processed separately by age cohort over the 35 years consisted from 13 males and 13 females (Table 2). For the feedback of the participants or their parents or educators, each participant received a color graph with an explanation.

Table 1. Physical activity characteristics of the study sample (all)

Variable	All (n=47)	Males (n=21)	Females (n=26)
Number of valid days	5.9 (1.3)	5.9 (1.3)	6.0 (1.2)
Intensity of physical activity (mins/day)			
Sedentary	384.1 (84.1)	358.2 (84.0)	405.1 (79.6)
Light	273.2 (60.4)	287.0 (70.6)	262.1 (49.3)
Moderate	77.6 (31.1)	82.5 (36.1)	73.5 (26.4)
Vigorous	2.7 (5.6)	4.9 (8.0)	1.0 (1.1)
MVPA	**80.3 (33.6)**	**87.4 (39.7)**	**74.5 (27.1)**
Steps (steps/day)	18 807 (4289)	19 321 (4943)	18 392 (3727)
Meeting recommended activity level[1]	100%	100%	100%

Abbreviations: MVPA, moderate to vigorous physical activity.

[1] Recommended activity level: 10 000 steps per day

Results and Discussion

The whole group of participants demonstrated 4,289 steps per day (males 4,943, females 3,727), which is in all cases 1.7 times higher every day than the results of the general world adult population, including Czech population (Sallis et all, 2014).

The arithmetic mean of the PA intensity per day (moderate and vigorous) was 27.1 min for female, 39.7 min for male, 33.6 min for the total group. Although the recommendation for ordinary population was not followed our participants came close to it (recommendation is 30 minutes, our results were between 27 and 39 min). The results presented in this study differ from the authors (Foley et al., 2008; Frey, Stanish & Temple, 2008; Johnson, 2009; Longmuir & Bar-Or, 2000; Tudor-Locke, Washington & Hart, 2009). Válková (2007) assessed the group of Special Olympians aged between 12 -15 years, living in the special residential school (and trained teachers in adapted physical activity) with 53 min. moderate activity per day in the spring period.

Again, the data are higher than the data of the general population in this age. Although the monitored activities were co-educative and had a similar motion arrangement females confirmed to be less active in both aspects: amount of steps and minutes of moderate-vigorous activities per day. This findings are relevant to findings of other authors (Peterson, Janz & Lowe, 2008; Temple, Frey & Stanish, 2006). Gender differences were not confirmed in the Czech study Válková, Lu Qu and Chmelík (2014) in which participants of three-days SO athletic races achieved similar results in daily activity. Probably the competition regulation determining the participation of races in two events and one relay could influenced the volume of activities. It can be deduced that accessibility to PA is one of the factors that affects the volume and intensity of PAs of individuals with MD. Further we can deduce, too, the inclusion in athletic events (lower level event) is more strongly linked to an athlete's mental level rather than gender. Studies (above) describe lack of PA of individuals with MD as a finding fact, mostly they do not indicate options and accessibility. It should be perceived that the presented assessment was realized during outdoor sports-relaxation camp with controlled program. The leaders of the camp divisions and the author (participant of this outdoor camp) thought that participants were not too active and expected higher activity comparing to previous years. Probably the aging begins to appear. From this point of view the findings relevant or higher compared with general population were surprising. On closer analysis, it was essential to find out that the accommodation of the participants was in scattered tourist chalets which surrounded a central building (sanitary facilities, a dining room, a common room). Participants had to pass and manage this distance several times a day.

The importance of the closest environment and surroundings was confirmed by Mokrošová (2013). She compared PA among clients of three centers of social services located in the different areas. There were at least 15 monitored persons in each center. The most walks a day during the weekday were shown by clients in the so-called walking distance from the center (1,750 steps per day). The clients of the other center, even with the garden facility, but with clients lodging far away, which was the traffic, did not achieve these results (only 1,605 steps per day). However, in spite of a lower amount of steps a higher number of minutes with moderate and vigorous activity clients achieved (103 minutes per day). This confirms the need for a balanced environment for the realization of physical activities. Walkability and urban setting is stressed in the worldwide study of Sallis at al (2014).

Table 2. Physical activity characteristics of the study sample (35+ years)

Variable	All (n=26)	Males (n=13)	Females (n=13)
Number of valid days	6.3 (1.0)	6.2 (1.0)	6.4 (1.0)
Intensity of physical activity (mins/day)			
Sedentary	414.6 (67.9)	386.3 (76.7)	442.9 (79.6)
Light	250.6 (53.2)	258.6 (64.3)	242.5 (49.3)
Moderate	62.2 (25.7)	67.1 (32.5)	57.3 (26.4)
Vigorous	3.0 (7.2)	5.3 (9.8)	0.7 (1.1)
MVPA	**65.2 (30.3)**	**72.4 (39.1)**	**58.0 (16.5)**
Steps (steps/day)	16 628(3482)	17 113 (4056)	16 143 (2881)
Meeting recommended activity level[1]	100%	100%	100%

ABbreviations: MVPA, moderate to vigorous physical activity.

[1] Recommended activity level: 10 000 steps per day

The second aspect was the age aspect (Table 2). We evaluated the age group in nearly seniors age. The average age of 13 males was 45.5 years in the range from 35 to 63 years of age; the average age of 13 female 42.6 years in the range from of 36 to 62 years of age. Even average age of male was a little older than female they showed higher activity. Despite the fact that conclusion cannot be generalized due to a small number of the members in both groups, the results tend to be a declining trend. Not only in the number of steps (males 4.056, females 2.881, group as a whole 3.482 steps), but also in minutes moderate + vigorous activity per day (males 39.1, females 16.5, group as a whole 30.3). Again, there is confirmed the lower activity in female group, only 16.5 minutes daily moderate + vigorous activity versus 27.1 min in complete female group.

All the evident items above indicates that the outdoor Special Olympic program based on EKS principles can help people with a mental disability to live an active lifestyle, which is relevant to mentioned findings of authors presented in this article: e.g. Johnson (2009) who states that children and adolescents with mental disabilities derive health benefits from participation in group exercise programs. Or Sallis et al. (2014) who stressed available (walkable) environment.

Conclusion

The submitted survey shows that persons with mental disability are able to participate not only in a guided program in outdoor activities but also in an investigation that requires responsibility for the six-day wearing of ActiGraphs and with the support of leaders to record the course of activities. Research with 47 SO participants documented that the persons with mental disability (Special Olympians) can achieve a higher level of physical activity under a guided program which we presented in our study.

The physical activity levels of participants were higher than published in academic articles. Against the presented studies above, our participants achieved values comparable to a common population in similar age during their outdoor camp which supports the idea of creating opportunities to involve people with mental disability in the PA.

At the same time, it confirms, as the intact population a) lower activity in a females group even this group passed a relatively consistent program like males group, b) natural decline with respect to age, mild in men and marked in female group. The outdoor activities based on principle of Eunice Kennedy Shriver camp are beneficial for people with mental disability.

Even though the research study is limited with only 47 participants and to extraordinary conditions of outdoor camp, the results can lead to continuous research and further optimize the development of PA programs for people with a mental disability. The project should be repeated with the same participants during their regular week and in relations to their BMI, fitness variables and local environment.

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PSYCHOLOGICAL CHARACTERISTICS IN SPORT TALENT DEVELOPMENT

Vičar Michal
Faculty of Sport Studies, Masaryk University, Brno, Czech Republic

Purpose: Numerous studies identify and investigate psychological characteristics of elite athletes. They compare elite and the less successful athletes with the intention to reveal the reasons behind excellence of some athletes. These attributes, often termed Psychological Characteristics of Developing Excellence, also comprise several mental skills. They underpin quality and development of talent. These psychological characteristics are trainable and their improvement in sport leads to better performance in both long and short term perspective. Clear distinction of the key psychological characteristics is still missing in sport psychology literature. The purpose of this study is thus to identify the main mental skills connected with sport talent development. This will serve as a stepping stone for future creation of a diagnostic tool to measure their quality which may be utilized in sports talent identification.

Methods: Problem analysis and conceptual analysis based on 4 different approaches are used in order to identify the key psychological characteristics.

Results: Based on the extensive literature review, the following psychological characteristics and mental skills were identified: Self-efficacy, commitment, imagery, attentional control, coping with pressure, realistic performance and skill evaluation, goal setting, mental toughness, self-awareness

Conclusion: Psychological characteristics developing excellence and mental skills associated with talent development in sport were identified. They serve as a solid base for future creation of diagnostic tool development.

***Key words**: mental skills, psychological characteristics of developing excellence, peak performance, sports talent, mental training*

Introduction

We often hear stories of “talented athletes” wasting their talent away. Their coaches can do nothing but sigh. If only their charge “used their head”, they could have achieved much better results. According to them, the athletes did not control themselves or their emotions and were constantly distracted. Sometimes, the coach would add how lazy they were. A great number of elite athletes, however, assert that they were not endowed with any unique predispositions. Their elite skills are only attributable to their hard work and unceasing personal development.

This article discusses the psychological characteristics playing a key role in sports talent development – Psychological Characteristics of Developing Excellence (PCDEs).

There has not been unified agreement on the specific characteristics included in PCDEs. Based on a comparison of various authors' approaches, the principal characteristics will be defined within this article as a baseline for a psychodiagnostic method.

The concept of PCDEs is relatively new within the field of sport. It was first used by MacNamara, Holmes, & Collins (2006). PCDEs comprise personality traits and developed psychological skills, which play a crucial role in the transformation from having potential into performing athletically. They also contribute to learning efficiently and overcoming adversity. They are projected in performance and optimise training and progress in sport (Freeman, 2001). PCDEs are not limited to mental skills; they also accommodate attitudes, emotions and desires necessary for success (Martindale, Collins, & Daubney, 2005). They are equally applicable outside of the sports world (Gould, Diffenbach, & Moffett, 2002). Studies on PCDEs help young athletes effectively utilise the possibilities of development and progress that they encounter throughout their life (Côté & Hay, 2002; Van Yperen, 2009). These strategies are, for this reason, considered to be especially beneficial in enhancing training sessions, as they aid deliberate practice (Ericsson, Krampe, & Tesch-Römer, 1993). This is why PCDEs play a key role in the transformation from having potential into being successful in sport. In the long term, the development of these characteristics should result in efficient self-regulation (Schoon, 2000). Self-regulation helps us direct our feelings, thoughts and behaviour. It denotes a possibility to conduct with the aim of achieving short-term and long-term goals by the means of self-monitoring and self-influence (Hartl & Hartlová, 2000). It is comprised of self-awareness, self-recognition, self-education and self-reflection.

Athletes with high level of self-regulation are endowed with a number of desirable abilities in sport. They are able to assess their performance, control emotions such as aggressiveness and pre-competitive anxiety, focus on self-development and seek help when beneficial, to name a few examples. They can effectively and independently train and operate even without permanent coaching guidance or supervision (Collins, Button, & Richards, 2011). They can regulate their internal psychological settings in a desirable manner and effectively deal with their environment and stress resulting from it (Ravizza, 2001). These athletes organise their life so that they are able to balance their sports, non-sport activities or obligations, and relaxation. The function of self-regulation strategies serves as a good tool in identifying young athletes who could successfully advance from youth league to elite level (Toering, Elferink-Gemser, Jordet, & Visscher, 2009). One example of it is a study by Jonker, Elferink-Gemser,

& Visscher (2010), where a group of successful athletes were able to acquire new skills more effectively through the use of self-regulation strategies. On the other hand, competitors with low self-regulation tend not to assume responsibility for their own development. There is a possibility that their performance might gradually stagnate; they might lose interest in the activity which leads to a decrease in the numbers of elite athletes (Vičar, 2017a). These findings imply that using PCDEs is crucial for the transformation from having potential to performing athletically.

Methods

Problem analysis and conceptual analysis are used in order to identify the key psychological characteristics. Suitable characteristics upon which to base the final list of theme seem to be those that take into account traditional approaches in addition to those of MacNamary et al (2006). These concepts are:

Mental links of Excellence (Orlick & Partington, 1988)

Mental Skills in Sport (Natalie Durand-Bush & Salmela, 2001)

Self-Constructs about Skills (Mudrák, 2011)

These concepts are supplied with a list of psychological characteristics created by the author of this article, who actively deals with the topic sports talent (e.g. (Vičar, Protič, & Válková, 2014; Vičar & Válková, 2014; Vičar, 2017a).

The first attempt to identify principal characteristics determining elite performance was conducted by Orlick and Partington (1988). Based on wide research of literature and results of many qualitative and quantitative studies, the authors identified the most essential characteristics necessary for development of sport expertise. They named these characteristics *mental links to excellence*. Following their train of thought, Durrand-Bush and Salmela (2001) created a theoretical base comprised of mental skills for the OMSAT-3* questionnaire. The questionnaire was translated into Czech by Vičar and Hřebíčková (2017). Mental skills are athlete's psychological characteristics, which determine, to a considerable extent, their sport performance. In general, development of sports talent is conditioned by acquisition of these skills. Mudrák (2011), on the other hand, deals with the attitudes athletes maintain towards themselves. These attitudes strongly affect performance motivation. He asserts that what athletes think of their own talent and performance is crucial.

Table 1 shows all psychological characteristics theorised by the aforementioned researchers, including the stance of the author of this article. They are combined into groups in order of their frequency.

Table 1. Psychological characteristics necessary for development of excellence, according to various authors.

Mental links of Excellence	Mental Skills in Sport	Psychological Characteristics developing excellence	Self-constructs about skills	Researcher attitude
4 TIMES LISTED				
Self-confidence	Self-confidence	Self-belief/self-confidence	high self-efficacy	high self-efficacy
Commitment	Commitment	Commitment to excelling in their chosen domain	High self-determination	Commitment
			High subjective values of goal and expectancy of success	
3 TIMES LISTED				
Imagery	Imagery	Imagery		Imagery
Focus and distraction control	Focusing	Focus, concentration and distraction control		Attentional control
	Refocusing			
Coping with pressure	Stress reaction	Coping with pressure		Coping with pressur
	Fear control			
Constructive evaluation		Realistic performance evalutions	Incremental implicit theory	Apropriate Self-awer
Goal-setting	Goal – Setting		Goal orientations	Goal - setting
2 TIMES LISTED				
Planning and organizational skills	Competition planning			
ONCE LISTED				
Quality practice	Relaxation	Social and communication skills		Mental toughness
Mental readiness	Activation	Keeping things In perspective		Hardiness
	Mental practice			

Selection of the principal psychological characteristics was preceded by the following steps:

Related concepts introduced by individual authors under different terms were placed in the same group.

Each characteristic was required to appear in works of more than two authors.

Characteristics referring to the same superordinate phenomenon were grouped together.

Where notions referred to component parts of a superordinate phenomenon, the superordinate term was employed (e.g. focusing, refocusing X attentional control)

In the field of sport, "self-efficacy" is preferred to "self-confidence". Compared to self-confidence, self-efficacy is activity-specific (i.e. it entails one activity). It is associated with long-term development (Bandura, 1997). Self-confidence is considered to be an attribute related to one's personality in a wider context and is linked to immediate performance (Schunk & Pajares, 2002).

Characteristics defined by Mudrák (2011) refer to attitudes. While self-determination and subjective goal values are related to commitment and motivation strength, incremental implicit theory is interconnected with one's own abilities and performance. Goal orientation refers to a set goal characteristic. These characteristics were matched with other authors' respective constructs in cases where they broaden their interpretation by an attitude component.

Results

Below is a list of psychological characteristics necessary for elite talent:
Self-efficacy, commitment, imagery, attentional control, coping with pressure, realistic performance and skill evaluation, goal setting, mental toughness, self-awareness

Discussion

Selected psychological characteristics are believed to influence the development of talent in sport. Concentration, distraction control and efficient training support the process of skill acquirement. Realistic performance evaluation contributes to making the best possible use of training. Self-awareness and self-monitoring are an indispensable prerequisite for control over thoughts and emotions. Goal setting directs an individual to conceptual work. Self-efficacy contributes to the selection of adequate challenges and, together with invincibility, it aids in coping with failure. Stress management is useful in working with flow, pre-competitive states and nervousness. Commitment supports overcoming crisis periods and is important for persistence with long-term training. Imagery helps develop motor skills and cope with difficult competition situations.

PCDEs and self-regulation are not usually represented in the traditional models of talent development (Vičar, 2017c). These characteristics are, however, reflected to a high degree in the dynamic approach to the quality of sports talent (Gagné, 2004; Simonton, 1999; Vičar, 2017b). They allow the athlete to maximise their predispositions. Their level, therefore, might be assessed in order to create a basis for future development.

Krane & Williams, (2010) point out the ambiguousness in the relationship between mental skills, psychological characteristics and sports performance. They state that all popular studies written on this topic were either descriptive or correlative. Interpretation of their results should be thus performed with caution. The majority of the studies presented description of athletes' experience and feelings, or identified the link between mental skills and elite performance. No conclusions on the relationship between cause and consequences could thus be drawn. The dilemma is yet to be solved of whether athletes first acquire the mental skills necessary to achieve the ideal mental state or whether these characteristics only develop based on the athletes' continuous success. It can, therefore, not be stated with certainty that the aforementioned mental skills are the cause of the characteristics' development. Within the dynamic approach to sports talent development, they can, however, serve as an indicator of talent.

The acquirement of PCDEs in children does not automatically guarantee their future elite performance. It does, however, provide them with the opportunity to develop the most advanced skills possible, in accordance with the philosophy: "we should be all that we can be". This approach equips children not only with the characteristics necessary for successful sports talent development in the early stages of their growth but also with the abilities necessary for their future growth. This can apply to elite sport as well as daily life.

Conclusion

In this article, we identify key psychological characteristics necessary for the development of excellence in sport performance. Development of these characteristics enables athletes to achieve a high level of self-regulation, which manifests itself in the ability to fully employ one's potential. Selected psychological characteristics should be endowed with their operational definitions in future and form the point of departure for creating a psychodiagnostic tool that would help identify these key characteristics.

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INTEGRATING PHYSICAL EDUCATION AND GEOGRAPHY IN THE REALISED CURRICULUM – A QUESTIONNAIRE SURVEY IN THE CZECH REPUBLIC, THE REPUBLIC OF SLOVENIA AND DENMARK

Vlček Petr, Hana Svobodová
Faculty of Education, Masaryk University in Brno, The Czech Republic

Abstract

This paper aims to address the lack of international knowledge and research in interdisciplinary curriculum development and teaching in the subjects of Physical Education and Geography. The aim of this international study, between universities from the Czech Republic, Denmark, and the Republic of Slovenia, focuses on a comparison of questionnaire survey outcomes among teachers in these subjects. The main problem focuses on how Physical Education and Geography is integrated and combined in the real school life.

Keywords: *Physical Education, Geography, curriculum, cross-curricular interdisciplinarity, integration, comparison*

Introduction

In the pedagogical and didactic fields, interdisciplinary cooperation is one of the main topics that both professionals and teacher-practitioners discuss and write about[7]. This means that interdisciplinary cooperation is increasingly making its way into schools. Hayes Jacobs (1989) describes it as "…a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to combine a central theme, topic, issue, problem, or work".

Even though many teachers, teacher educators, curriculum developers, and some politicians see interdisciplinarity as an important issue, there is a lack of knowledge and research concerning the international comparison, especially when it comes to the subjects of PE and Geography.

As the debates about interdisciplinary cooperation can differ in different countries according to actual settings of school curricula, the following text presents views and ideas of Czech, Danish and Slovene authors contributing to the discussion.

Methods

The aim of this international study, between universities from the Czech Republic, Denmark, and the Republic of Slovenia, focuses on a comparison of questionnaire survey outcomes among teachers in these subjects. The main problem focuses on how Physical Education and Geography is integrated and combined in the real school life.

The questionnaire survey was carried out in the school year 2015/2016, in the three countries the Czech Republic, the Republic of Slovenia, and Denmark in order to determine how experts (teachers in lower and higher primary classes, university experts, or other specialists) perceive the integration of physical education and geography. The questionnaire survey was developed using Google Docs forms and completed on-line by participants.

The questionnaire contained 11 questions, four of which were identification questions – about the respondents' country of origin, their sex, age, and contact details. Further questions enquired about the respondent's experience with the integration of physical education and geography, in their studies or in practice. The respondents were to state whether or not they regarded integration as important, and if they did, they were asked to list goals and examples of integration. If they did not consider integration important, they were asked to provide reasons and potential barriers and problems related to integration. The results can be further sorted according to the length of the respondents' teaching practice.

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7 Due to its many different forms, interdisciplinary integration is one of the concepts in the didactic field that has gained many conceptual labels. The scientific literature contains a number of professional terms that, on the one hand, demonstrate the diversity of the concept, while on the other hand, create a conceptual mess (Peterßen, 2000). Noteworthy terms include: learning correlation, correlation in teaching, cross-curricular correlation or correlation between school subjects, correlation or integration of learning content, cross-curricular links or integration, and interdisciplinarity. The following terms are also found: complex teaching, integrated instruction, cross-subject teaching, cross-curricular themes or links, cross-disciplinarity, transdisciplinarity, and, of course, integrative or integrated curriculum.

Questionnaire for teachers of Physical education and Geography

Table 1. Background information

<table>
<tr><td>Male / female (M / F):</td><td rowspan="4">The main school level you teach:
1.–5./6. grade (X):
5./6.–9. grade (X):
Secondary school (lower grade) (X):</td></tr>
<tr><td>Age:</td></tr>
<tr><td>Years of teaching experience:</td></tr>
<tr><td>Country (Denmark, Slovenia, Czech Republic):</td></tr>
<tr><td colspan="2">Please write below the subject(s) you teach this school year (2015/16)</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

1. Do you have any **experience** (personal, colleague, during studies …) with **combining physical education and geography**?
YES
If yes, please give a short description (max. 5 lines):
NO
2. Do you find **combining** of physical education and geography **important**?
YES
If yes: Can you mention the 3 most important goals when combining physical education and geography (1. being the most important goal and so on).
NO
If no: Why not?
3. Can you see any **possibilities** to combine physical education and geography in primary/secondary education?
YES
If yes, please describe, how (in general or concrete activities)?
NO
If no, why not (describe barriers, problems or threats)?

Source: author´s own on-line questionnaire survey

A total of 69 responses were received; 14 from Denmark, 16 from the Czech Republic, and 39 from Slovenia. In close-ended questions (mostly identification questions), basic statistical methods (addition, average, and correlation) were used. For the remaining questions, given the number of respondents and the open nature of most of the questions, the survey is regarded as qualitative and all answers are included in the results. In these questions, the qualitative research method of key words analysis of individual statements was used. Actual statements from respondents are used for illustration purposes.

Results

Table 1 shows the breakdown of respondents according to gender and age. The numbers of men (30) and women (39) are quite even. Most respondents are aged between 50 and 59 and the average age of respondents is 42.9 years. The length of teaching practice is proportional to their age. A correlation coefficient calculated by means of function CORREL in MS Excel from the age of respondents and the length of their teaching practice amounts to a value of 0.9418, which represents almost a linear relationship between these two quantities. The average length of the respondents' teaching practice is 16.9 years.

Table 2. Characteristics of the survey's respondents according to their gender and age

Age	Female	Male	Total (abs., rel. in %)	
< 29	5	5	10	14.5 %
30–39	9	10	19	27.5 %
40–49	7	9	16	23.2 %
50–59	8	13	21	30.4 %
> 60	1	2	3	4.3 %
Total	30	39	69	100.0 %

The overwhelming majority of respondents were teaching in primary education when they were asked to fill in the questionnaire. Five respondents were working in a different type of education such as a university. Seven teachers teach only in lower primary classes (typically Grades 1 to 5 but including Grade 6 in Slovenia), 49 teachers teach in higher primary classes (or lower secondary level (Grades 5/6 to 9) in Czech gymnasia), the other eight teachers work at both levels.

The combinations of subjects taught by the respondents are diverse. Respondents teach physical education most often (41), either as the only subject or combined with another subject (most frequently a language, geography in seven cases, or mathematics). A total of 20 respondents teach Geography, either as the only subject or combined with another subject. Ten respondents teach almost all subjects in lower primary classes.

A total of 33 respondents have personal experience with the integration of physical education and geography (i.e. the respondents experienced integration during their studies or they know a colleague who is involved in it, or they are involved in integration themselves), while 36 respondents have no experience. Interestingly, teachers without experience of integration are more likely to think that integration is not important. A total of 55 respondents including even the 19 respondents who lack the experience, consider the integration of physical education and geography important (see Table 2).

Table 3. Matrix of respondents' responses regarding their experience with the integration of physical education and geography, and the importance of integration

		Do you find combining of physical education and geography important?		
		Yes	No	Total
Do you have any experience (personal, colleague, during studies …) with combining physical education and geography?	Yes	31	1	33
	No	24	12	36
	Total	55	13	69

Integration is considered very important by all teachers who teach both physical education and geography; 25 (71 %) of physical education teachers and 11 (84 %) of geography teachers see the integration of exercise and geography as important. However, geography teachers, no matter whether they teach geography only or in combination with another subject, adopt a more favourable attitude towards the integration of physical education and geography than teachers of physical education.

Three core activities were frequently given as examples of personal experience with the integration of physical education and geography; each of them was mentioned in approximately one third of all responses although some responses mentioned more activities:

- orientation in nature with map, compass, GPS and orienteering (36 % of responses),
- outdoor teaching (34 %),
- excursion, outdoor sport/project day (30 %).

The respondents were also asked to list their three most important goals when combining physical education and geography. The results reveal four key goal areas:

- for enhancing the learning process from the student's and teacher's point of view.

"By being outdoor, students can feel the nature, smell it, touch it; not only see it from the classroom."

"As teacher you can describe landscape from different point of view."

"Working in more holistic way such as projects within school work."

"Be being active. Students can observe the landscape in a different, more active way."

"Students work out and study in one time."

"Fieldwork = reasons and consequences."

"To stimulate learning."

“Learning by doing.”

“Learn to work interdisciplinary.”

“Active approach to teaching (both students and teachers).”

“Learning through other means than usual.”

“Better explanation and understanding of problem.”

“Movement promotes learning.“

“The education in real environment.“

“Convert theoretical knowledge into practise.“

“Learning with (all) senses.“

for health

“Be fit.“

“Increase physical fitness and residence of students.“

for communication and cooperation

“Better communication and cooperation between students.“

“Enhancing team work.”

“More fun.”

for real life

“Understanding the World we live in.“

“Complex development of students.“

> “Linking knowledge and skills from different subjects and their application in practise.”
>
> “The care for open clean, less polluted environment in the future.”
>
> “The combination might give a better picture of why, how and what to do in nature in a more sustainable way.”

If respondents did not consider integration of physical education of geography important (13 respondents), they were asked to explain their reasons. The most frequent reason (five respondents) was *“I do not see any connection“*. Another reason given is that physical education and geography are not suitable subjects for integration. The combination of physical education and biology was mentioned as one offering better possibilities. Other reasons included time constraints and the fact that such integration is not part of the curriculum. In particular, teachers mention the fact that such lessons are very demanding in terms of organization, and that teachers have not been professionally trained to integrate the two subjects. One of the teachers asked why pupils should be forced into integration if boosting their attitude to sport and exercises would be sufficient.

Although more than 50 % of teachers and experts have no experience in integrating physical education and geography (36 respondents as compared to 33) and some of them cannot see reasons for doing so, 60 out of 69 respondents could see potential in the integration of physical education and geography in lessons. The integration via orientation in nature with a map/GPS and orienteering is most often mentioned (18 responses). Other activities include sports days or courses (cycling, biking, canoeing, skiing, mountaineering and caving), school outdoor stays, and other outdoor activities. Other non-traditional activities mentioned are disc golf with a compass, playing settlers in large format, geocaching or where I go, parkour in urban environments and battle games in woods. Some teachers even see the possibilities of integration in for example, collecting rocks, transport planning, or ecological lessons. One of the teachers, however, points out the indispensable knowledge of first aid and awareness of risks connected with outdoor lessons.

Respondents were given space for free comments at the end of the questionnaire, which only a few of them took advantage of; however, two interesting views were provided: *“Geography is a multidisciplinary science. Through educational system, tourism and economy, a placement of sport facilities and national health strategy strongly connects geography with physical education.“* or *“Great to be PE and geography teacher!“*

Discussion

Integration of elementary school subjects is emphasized to varying extent in all the curricula of all three countries and there are considerable opportunities for integration of the Geography and PE curricula (Vlček et al, 2016). Nevertheless, the results of the questionnaire survey showed that while interdisciplinary integration is often mentioned and encouraged in the curricula documents and most teachers believe that the integration of PE and Geography is important, the subjects have not been integrated sufficiently. It is important to note that responses from the countries concerned did not differ in essence – while integration is often mentioned in the curricula, in practice it has not been implemented adequately. The main reasons are the organisational demands of this type of teaching and a lack of knowledge on the part of the teachers. The research also showed that, from the teachers´ point of view, outdoor learning is the focal point of interdisciplinary integration between geographic subject matter and PE and sport. Teachers with experience of integration are more likely to think that integration is important than teachers without experience. Unfortunately, more than half of the respondents have no experience in integrating PE and Geography, either in their studies or in practice. Some experienced respondents mentioned that such lessons are very demanding in terms of organization, and that teachers have not been professionally trained to integrate the two subjects.

For these reasons, it is absolutely critical that further research and teacher training in interdisciplinary integration be undertaken. Such research projects are currently underway at the Masaryk University (project of Czech Science Foundation, "Fieldwork as a powerful learning strategy - 16-00695S".).

Conclusion

Interdisciplinary cooperation initiatives are aimed at transforming it from a sporadic (occasional) or random approach to a systematic or planned one, and above all, towards connecting subjects. The main purpose of the interdisciplinary approach is to overcome the fragmentation of knowledge and provide students with lasting and useful knowledge and skills. According to Cone, Werner and Cone (2009, p. 2) "*education can be seen as a process of change that continues throughout a lifetime*". The type of learning experience we have while in school underpins how we integrate everything we learn, as well as how we transfer knowledge and skills from one experience to another. These authors also claim that the foundation of interdisciplinary education is our innate need to make meaning from discrete pieces of understanding. In 1989 Hayes Jacobs said that "*there is no longer as much discussion among educators about whether to blend the subject areas, as about when, to what degree, and how best to do it*" (Drake & Burns, 2004, p. 1–2).

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BEHAVIOR OF SLAVIA PRAGUE FOOTBALL FANS: SOME SELECTED ETHICAL ASPECTS

Hurych Emanuel [1], Scholz Petr [2]
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic[1]
College of Polytechnics Jihlava, Czech Republic[2]

Abstract

The purpose of this research deals with the fact that football (soccer) is one of the most popular sports all over the world but this beautiful game has its dark side, as well: corruption, homophobia, violence, and racism. Within our research we focused on one specific category of visitors – football fans. We divided fans into five types according to their motivation and differences in their behavior. This kind of division was based on the theoretical and practical studies which have been published mostly in the last two decades.

Our empirical research was focused on the fans of Slavia Prague (a Czech football club). Within the survey we obtained and analyzed data about relationship between fans' verbal and other expression and about their violent behavior.

Primary data were collected by a questionnaire survey mainly at the Eden stadium in 2015 and 2016. A total of 462 respondents (aged 26.29 ± 10.19 years old) participated in this research and all the respondents were attending in a stand of home team supporters.

In our research, we found that expressions of demolishing the stadium and other disturbances are considered the most serious expression of violent behavior by 79.22% of the fans. On the other hand, 77.06% of the fans stated that boo is the least serious problem.

The final aim of this paper is to consider and discuss some concrete outputs coming from the empirical research within the ethical discourse. While the utilitarian position presents one possible viewpoint for the ethical approach, the deontic position provides a bit different ethical platform. Because of the limited space for this complex issue we focused on defining the main structure of different kinds of behavior and their ethical consequences in both the deontic and utilitarian perspectives.

***Key words**: aggression, deontic position, football club, utilitarian way of thinking, violence*

Introduction

Sports spectatorship is a social phenomenon that can be analyzed from several different perspectives. Socio-psychological aspects of this phenomenon primarily take notes of the motivation for spectator attendance, spectator experience, links between spectators´ relations to clubs. The reactions of spectators to the selected game situations and ways of preventing negative manifestations of spectator are not disregarded (Sekot, 2010). The behavior of sport fans has been the subject of interest for many years, not only in Britain but also in other European countries. Violent behavior of fans is, therefore, also known as football hooliganism and sometimes named English disease (Frosdick & Marsh, 2005). Precisely the issue of football hooliganism has become the subject of intense media, political and academic interest in recent years. The Czech Republic in this regard presents no exception, although we can say that the hazards of football hooliganism are considerably smaller on the Czech territory than in some other countries (Scholz, 2016).

Unfortunately, oftentimes ignorance and lack of understanding of this phenomenon determine a view on it. It is important to distinguish hooligans from other people who watch football matches. In this context, it is possible to identify four major groups, namely: football spectators, football fans, supporters, and football hooligans (Smolík, 2008). In this paper, we will focus on a group of *fans*. Our research is devoted to the fans of one Czech football club – Slavia Prague.

Classical fans (“normal”). These are the individuals who attend football games regularly, have a relationship with their clubs, often because the stadium is located relatively close to their residences. The fan has certain expectations for the course of the match and, by identifying with the team, experiences the highs and lows of the club. Football is usually the only favorite sport for the fan. Football fans present their identification mainly with clothing, e.g., replicas of jerseys, club scarves, baseball caps, T-shirts, flags, badges etc. For this football fan, the division into “we” (supporters of the club) and “they” (fans of other clubs) is characteristic (Slepička, 1990). These fans can be found mostly on the main terraces, in some cases they can even get carried away by loud cheering, sometimes with racist overtones. We note that this group of spectators usually does not get involved in other manifestations of spectator violence, except for random throwing of objects on the pitch.

Marsh, Rosser & Harré (1978), based on observations, classified seven types of social roles among active fans in the end. These are the so-called Chant leader, Aggro leader, Nutter, Hooligan, Organizer, Fighter, and Heavy drinker. Smith (1988) states that it is necessary to distinguish the so-called serious fans from regular fans. The main difference is found in the fact that the serious fan expects and utterly believes in their team winning. Hunt, Bristol & Bashaw (1999) define a football fan as an enthusiastic lover of football. Real & Mechikoff (1992) have a similar view to the distribution, and besides the "classical" fans they distinguish the so-called devoted fan who identifies with the club. According to the motivation and differences in behavior, we can identify other five types of fans:

Temporary (provisional) fan. According to Hunt, Bristol & Bashaw (1999), an important aspect is to understand the sports fan's own decisions. Being a fan is an essential part of defining themselves and presenting their own identity to others. The interest of the temporary football fan is limited in time. It may be a few hours or even years. Once the interest subsides, the temporary fan has no reason to show their relationship to football or club.

This is e.g. a fan of a club that thrives, wins their matches or even the title. In our case it is SK Slavia Prague – the club which in the 2007/2008 and 2008/2009 seasons won two championship titles, showed attractive football, visits to the home games exceeded over 10,000 visitors and those times it was modern and "in" to support Slavia. In subsequent seasons, considerable economic problems, rumors about the unknown owner of the club and disputes in the leadership of the club were noted, Slavia fought for its existence etc., and many fans turned away from Slavia. *Local fan.* If the temporary fan is bounded by time, in the case of the local one, a geographic boundary takes place. The local fan is a fan, who is linked with the club through the geographic region where, for instance, they were born or where they live now (Hunt, Bristol & Bashaw, 1999). Just the two most common reasons are stated by Jones (1997), as for why the fan supports their favorite club; it is a local club (53%), or a hometown of the fan (10%). Hunt, Bristol & Bashaw (1999) conclude that if the local fan supports their club due to their favorite player who is traded or sold to another club, then the interest of the fan in the club declines.

Devoted fan. For this category, there are no limits as in the previous types of fan. This type of fan is initially likely to be crystallized from the temporary or local fan. The main difference is found in the degree of devotion as opposed to temporary fan. The identification with the club is also larger and deeper in comparison with the local fan (Hunt, Bristol & Bashaw, 1999). Devoted fan wants to participate in all matches of their favorite club and it may not always be the club that plays Champions League regularly or wins titles (Tottenham Hotspur). They watch the match of "Spurs" on TV, on the Internet, buy products in fan shop, participate in signings of players etc.

Fanatical fan. This is a fan who has many characteristics in common with a devoted fan. Their behavior exceeds the threshold of a devoted fan, but this behavior is respected by their loved ones (family, friends etc.) because it is the support of the team or player. Their body is often decorated with tattoos and colors of the club, or they even can go to matches in costumes. Some fanatical fans have an emblem of their favorite club painted on the front of the house, redecorated a room in the colors of the club, have bedding of their club etc. (Hunt, Bristol & Bashaw, 1999).

Disturbed fan. The difference between disturbed and fanatical fan is in the fact that the fanatical fan finds the essence of being a fan as an important part of self-identification, whereas the disturbed fan finds this essence of being as a primary form of self-identification. His behavior is anti-social, disruptive or abnormal. He easily plugs into fights and violence is not strange to him. Their behavior is disguised, and explained and justified by claiming that this type of behavior is typical for a football fan (Hunt, Bristol & Bashaw, 1999).

Methods

The goal of the research paper was to analyze the relationship between fans' verbal and other expression and their violent behavior at football stadiums in the Czech Republic. After having stipulated the aim, a research question was set. RQ: Which attitudes, expressions, and speeches are considered most serious by football fans of Slavia Prague?

Primary data were collected by a questionnaire survey mainly at the Eden stadium and other football stadiums in the Czech Republic in 2015 and 2016. The questionnaire consisted of twenty-nine questions; some of them were scalable, where respondents rated on Likert scale (1-5) individual verbal and other expression and their violent behavior speeches. The least serious activity was rated 1, the most significant activity received the highest grade, i.e. 5. This paper uses quantitative research, methods of analysis, mathematical and statistical methods. For the evaluation of the results, Statistica program was used. Some more detailed descriptions of the aims of the empiric research have already been published (e. g. Scholz, 2015, or Scholz, 2016).

The research was focused on the oldest football club (est. 1892) in the Czech Republic. The next reason for choosing this football club was finding that stands of the stadium (end) are the most occupied by football fans. The stand of the stadium for the home supporters is called the end, with the capacity of 3.065 seats. It consists of 5 sectors with 25 seats in 28 rows each. The end is mostly filled up to 2/3, and sold out during matches with attractive away teams e.g. Sparta Prague, Plzeň, and Baník Ostrava.

The selection of respondents was based on carefully pre-defined factors; e.g. seats 1, 3, 5, 7 in the first row; seats 2, 4, 6, 8 in the second row etc. from all the rows. The respondents were informed about the research and anonymity of the questionnaire. Once they answered the questionnaires, each of them received a small Slavia club badge. They had also the opportunity to contact the interviewer on the email stated on the questionnaire list and get themselves informed about the research results. Filled in questionnaires by 467 fans were selected of the total 720 questionnaires. Five questionnaires from fans were answered incorrectly and incompletely, therefore, they were not included in the research.

A total of 462 fans aged 26.29 ± 10.19 years old participated in this research and all the respondents were attending in the end.

The ethical aspects of the research and its results were dealt in the part devoted to discussion and conclusions.

Results

a) Social and demographic statistics

The sample consisted of 462 people aged 26.29 ± 10.19 years; of which 372 were males (26.67 ± 10.17 years), 88 females (25.05 ± 10.14 years), and 2 persons did not indicate gender. More than 3/4 of fans (80.52%) were single, it illustrates the fact that most fans are between 10-17 years. Almost 15% of fans (14.72%) said they were married or had a registered partnership, divorced were 3.46% of fans, and the rest of the fans (1.30%) declined to give their answers.

More than 1/3 of fans (40.26%) lived with parents, other 34.20% of fans lived in relationship (husband / wife / partner / partner), less than 1/5 of fans (17.32%) lived alone. Further 5.19% of fans lived with their children and the same percentage of fans lived with grandparents, siblings, or former partners.

Over 80% of fans (81.39%) came from complete families, nearly 1/5 of fans (16.02%) do not come from complete families, and 2.60% of the fans did not wish to answer. There were other parameters followed within the demographic part of the questionnaire (educational attainment, professions, life satisfaction) which cannot be described here more in detail. The more detailed study containing some selected demographic aspects is under the preparation.

b) Fan attendance motivation and expressions

More than half of fans (58.44%) started attending football matches in their childhood, the other 28.14% of fans in the rest of adolescence and adulthood (13.42%). The last option was ticked mainly by women who participated in football matches with their partners. Almost half of fans (49.78%) attended the first football match with their parents, further 41.13% mentioned friends and fans, and less than one-tenth (9.09%) attended their first football game on their own. Currently, more than two-thirds of fans (70.13%) attended a football match with friends, nearly 1/4 of fans (22.94%) in the company of family and only 6.93% of fans attended the match without any followers.

Fans attended football matches for various reasons. More than half of fans (57.14%) said the main reason was cheering, then the atmosphere (42.42%) and entertainment (38.96%). More than 1/4 of fans (26.41%) stated that, during a football match, they got away from their private problems and job responsibilities. More than 1/10 of fans (12.12%) attended football matches because of the party. Through cheering, the fans mostly tried to support the club (62.34%), created an atmosphere (51.08%), unwinded (28.57%), weakened opponents (7.79%), and intimidated opponents (4.76%). Concerning the ownership of the club symbols almost every fan club owned symbols (93.51%).The most common symbols included scarves and jerseys, as well as Slavia T-shirts, silicone wristbands, wallets, and shorts. At home games, symbols of the club are always worn by more than 3/4 of fans (77.49%). More than half of fans (54.98%) always carried club symbols to away games, but more than 1/5 of fans (20.35%) did not have any club symbol for the matches that are played on the fields of opponents.

c) Fans´ expressions on mentioned activities

Pyrotechnics. Half of fans did not mind pyrotechnics (53.24%), and sometimes they helped with the actual firing, but it was rather an exception. They stated that the pyrotechnics belong to football and make the atmosphere complete, although they knew that launching pyrotechnics is prohibited at the stadium. Personal checks by the organizer before entering the turnstiles at the stadium are not so thorough, so some significant parts of pyrotechnics are smuggled into stadiums in clothing or by women, or alternatively, through the VIP entrance, where inspections do not take place. Almost a fifth of fans (19.48%) found this activity a serious problem, particularly with regard to safety and due to the interruption of the match, and then a forfeit. They argued that while handling pyrotechnics, there is a danger of burns, but so far, was not registered any case of burns at Slavia.

Booing. It was clearly identified as the least serious expression at the stadium. More than 3/4 of fans (77.06%) marked this behavior with the lowest mark. *Vulgar expressions.* As for vulgar chanting, the entire end or a vulgar individual, we can say that we have achieved approximately the same results. Vulgar expressions were addressed in particular at Dagmar Damková (former President of the Central Committee of Referees) and Miroslav Pelta (President of FACR), but also to the players of the opposing team (e.g. emotional celebration of a goal in front of Slavia supporters). Just 12.55% of fans considered vulgar expressions to be the most serious kind of behavior.

Physical aggression. More than half of fans (59.31%) considered the physical aggression against rival fans in the stadium as the most serious behavior. Nearly identical results were recorded in the physical aggression against the Czech Republic

Police or security. Fans attended football games primarily because they wanted to enjoy the game itself, or admired players.

Hooligan fight. Regarding the agreed hooligan fight outside the stadium, more than 1/3 of fans (33.77%) stated that this is a very serious issue and rated it highest mark, i.e. 5. One grade lower ratings were expressed by nearly a tenth of fans (9.52 %). These very fans regretted that the club is related to these skirmishes. Conversely, 28.57% of fans had no problem with an arranged conflict outside the stadium and sympathized with hooligans. Hooligan fights are part of their culture, and if this type of violence is not in the stadium, it is alright with the fans. On the other hand, if the opponent fan is dressed in the jersey and scarf and meets a hooligan, they need not worry. The true hooligans are much disciplined in this, they know what this culture is about and do not beat a fan.

Stadium demolishing. More than 3/4 of fans (79.22%) marked demolishing stadium and other riots the most serious behavior and absolutely unacceptable activity that should never be associated with Slavia Prague.

Throwing objects on the pitch. Almost half of fans (45.45%) believed that throwing objects onto the playing surface is also the most serious activity, which is confirmed by other19.05% of fans, who called it too serious. Most often it happens when the wrong verdict is made by a side referee or when celebrating a goal by opposing player in front of their home audience and the football pitch is sprinkled with empty or filled cups of beer, small coins or even lighters.

Pitch incursion. This activity did not reach such important values as we expected. It was ticked as the most serious behavior by 37.23% of fans.

Racism. Racism was regarded by more than half of fans (58.87%), who found expressions against dark-skinned players a very serious problem.

According to the findings of our field survey, we must conclude that football fans found the biggest problems with demolishing stadiums (79.22%) and racism (58.87%). Most respondents agreed that physical aggression against rival fans in the stadium (59.31%) and the Police of the Czech Republic or security (56.28%) was a very serious activity (Table 1).

Table 1. Fans´ expressions on mentioned activities in percentage

	1	2	3	4	5
firing of pyrotechnics	36.36	16.88	20.35	6.93	19.48
vulgar chants in the stand	36.36	28.57	15.15	10.39	9.52
individual vulgar expression	36.36	22.08	19.91	9.09	12.55
physical aggression against rival fans at the stadium	4.33	5.63	14.29	16.45	59.31
physical aggression against police and riot police	6.49	8.66	14.72	13.85	56.28
arranged hooligan fight outside the stadium	28.57	12.55	15.58	9.52	33.77
throw in the object on the pitch	6.93	9.09	19.48	19.05	45.45
demolishing stadium and other riots	0.43	3.03	4.76	12.55	79.22
expressions of racism	8.23	8.23	12.12	12.55	58.87
boos	77.06	9.09	9.09	1.30	3.46
pitch incursion	10.39	11.26	24.24	16.88	37.23

Note. 1 – the least serious expression, 5 – the most serious expression

Discussion

We can state that violence at the football stadiums is one of the most discussed topics in the Czech Republic. The media reported that just violent behavior is one of the major factors that discourage visitors and fans from enjoyable atmosphere of the football stadiums. We consider that this is not a true statement because football stadiums in the Czech Republic are safe for the 1st league matches.

We found that expressions of demolishing the stadium and other disturbances are considered the most serious expression of violent behavior by 79.22% of the fans. Other most serious problems were physical aggression against rival fans at the stadium (59.31%), expressions of racism (58.87%), and physical aggression against police and riot police (56.28).On the other hand, over 3/4 of the fans (77.06%) stated that booing is the least serious problem; other least serious activities were firing of pyrotechnics, vulgar chants in the stand, and individual vulgar expression (each 36.36%).

We can speak about two kinds of viewpoints which help us to approach the results within the ethical discourse: the process-oriented and the goal-oriented. Coming from the philosophical backgrounds we can find the difference between the deontic principle and the utilitarian position. While the deontic concept is more focused on running the processes, the utilitarian one isprimarilyled by the interest in the results and it is related to the final utility of the process.

Examining the results of our research from this point of view, we can divide the followed expressions into two groups according to their orientation – process-oriented or goal-oriented ones. This model is simplified, definitely, but it gives some possibilities for better understanding of football visitors´ motives.

We can omit the *arranged hooligan fight outside the stadium*because it presents a very specific (and different) part of the hooligans´(not fans´) culture. Concerning the rest of examined aspects we can establish two groups of the fans´ expressions. Mainly process-oriented features can be followed in: *vulgar expressions, expressions of racism, and boos*. On the other hand, the goal-oriented aspects can include those: *demolishing stadiums, physical aggression, pitch incursion, firing of pyrotechnics*and *throwing objects into the pitch*. This division comes from the evidence of very visible outputs within the second group – demolished seats, injuries of fans or policemen, the pieces of pyrotechnics in the ground, people moving on the playground.

The latter kinds of expressions were considered as the most serious by quite a high percentage of the respondents: 37.23–79.22% (an exception is presented with*firing of pyrotechnics*: 19.48%). The other group (process-oriented) provides rapidly lower percentage of high level of seriosity: *vulgar chants:* 9.52%, *individual vulgar expressions*: 12.55%, and*boos*: 3.46% (an exception is presented with expressions of racism 58.87%).

Conclusions

There is no statistical significance for the exact scientific outputs concerning the ethical conclusions. However, the ethical evaluation provided by the respondents displays quite a strong tendency to consider the seriosity of the expression according to their visible outputs. In our opinion (and concerning our group of respondents) we can argue that football fans´ evaluation of seriosity of some negative effects contained in behavior of different kinds of visitors is based more on the utilitarian position than on the deontic one. As a practical result it means that the respondents focus primarily on the material kinds of outputs which are more important for them than a proper evaluation of all the processes. Within the casual analysis it means a stronger focus on consequence than on the cause. This situation can bring some disbalance typical for many similar problem situations when the immediate status is considered and the causesare omitted.

From this point of view some our recommendations how to solve the described problems are limited in a global frame. In spite of this fact, we would like to present at least some particular proposals how to improve the situation:

To meet increasingly socially less negative phenomena in the terraces around stadiums, it is more than desirable that all existing preventive measures are now sufficiently utilized. Currently, the stadiums sell only non-alcoholic beer, sectors or ends for supporters are separated, tickets to riskier games are sold only upon production of identity cards, personal inspections are more thorough etc. For the future, also addressable ticketing and CCTV are also considered. In our view, the football clubs and the media should be more involved in the educational process through television broadcasts, as well as promoting fair play and critical evaluating the violence.

However, as the most important type of football violence prevention, we consider rising of public awareness, with the help of which it is possible to capture new incoming fans and prospective hooligans. The intention is to direct these people to positive cheering, i.e. without violence, group and individual vulgarities, racist insults, etc. An important aspect is the financial cost of security measures with regard to risk behavior of some groups of visitors, which probably should not be paid from public finances.

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SPORT MANAGEMENT

THE EFFECTS OF SPORT INVOLVEMENT IN A CORPORATE STRATEGY ON EMPLOYEE LOYALTY – FOCUS ON YOUNG GRADUATES IN ECONOMICS

Honcová Martina
University of Economics, Prague (The Czech Republic)

Abstract

Due to the recent low unemployment rate in the Czech Republic (Eurostat, 2018) companies face the problem with a lack of workforce. Therefore, it is crucial to find out how to attract new candidates and make employees want to stay longer. This paper investigates whether including sport in the company's strategy has an association with loyalty of its employees. The paper focuses on young graduates in economics as they have a wide range of possibilities on the labor market. The 85 respondents completed the online questionnaire where they answered questions related to the satisfaction and loyalty. The 72 respondents matched with the target group of the survey. There were three hypotheses on employee loyalty stated and tested through chi-square test on a significance level of 5 %. The research results show an association between the employee loyalty and sport involvement in a corporate strategy. The relation between attitude to sport of the employees and the evaluation of this strategy was not proved. Loyalty can be affected by employee satisfaction.

Key words: *employee loyalty, employee satisfaction, sport, strategy*

Introduction

The current economic situation in the Czech Republic is suitable to job seekers. The economy experiences growth (European Commission, 2018) and the unemployment rate is very low (Eurostat, 2018). The companies suffer from a lack of workforce and invent new ways how to attract new candidates and sustain their employees. The most complicated group in this relation are young absolvents (according to the e.g. LinkedIn findings, 2016). They benefit from the fact that they can easily choose from the wide offer of positions and if they are not satisfied with their job they do not hesitate to change it even within a short period. This may result in high costs connected to hiring process and initial trainings, opportunity costs and the time waste. Therefore, companies invent new steps that would strengthen the commitment of these employees so that they their loyalty to the company increases. This paper focuses on young graduates in economics who have a wide spectrum of job opportunities and tend to move from company to company. The paper aims to prove whether including sport in a corporate strategy in different ways has any connection to loyalty of young employees. As people have different attitude to sport, the research examines whether this strategy is perceived the same by all employees no matter what they think about sport. The paper also investigates whether employee satisfaction can have an association with the loyalty to employer.

There is a mutual correlation between company and its employees in terms of prosperity; a company can help its employees to feel satisfied and satisfied employees can help a company to achieve the best results. Loyalty is closely related to employee satisfaction and both are important indicators for company's success. Committed and work engaged employees are predispositions of high productivity and low employee turnover rate (Ibrahim & Al Falasi, 2014). Loyal and satisfied employees can also establish a good relationship with customers, suppliers and all stakeholders (Klopotan, Krešimir & Drožđek, 2016). Therefore, the companies aim to achieve the employee loyalty by using various tools. These tools are both financial and non-financial in character. It has been proved that direct financial stimulators (e.g. salary increase) are becoming no more popular, while indirect techniques (e.g. trainings, seminars,.) are increasingly better appreciated by employees and long lasting (Lazaroiu, 2015). The use of non-financial incentives can enhance loyalty by ensuring employee satisfaction or specifically job satisfaction. Satisfaction has two sides; personal and organizational. Both of them need to be taken into account by the employer (Chang, Chiu & Chen, 2010). Employees tend to identify significantly with an employer if they feel that their mutual attributes and characteristics are similar to what they consider important (Khan, Stanton & Rahman, 2013).

As a favorite leisure time activity sport can be associated with a lot of positive characteristics which are useful also in corporate life. Therefore, the companies may benefit from including sport in their corporate strategy in a lot of different forms, e.g. sport sponsorship, fitness or other facilities on a workplace, corporate sport events, sport benefits (regular sport activities, financial contribution on sport, Multisport card, The possibility to do sport within the boundaries of the firm can reinforce the adherence to the company. The communication within the company can be improved and simplified by a sporting event where people get closer to each other. This can result in a better productivity, collaboration and employee motivation (Pichot, Pierre & Burlot, 2009).

Another way of including sport in a sport strategy is sport sponsorship. The sport sponsorship effects can be viewed both from an external and an internal point of view. From an external perspective, sponsorship focuses on public, such as customers, communities, intermediaries and governments. Internally, sponsorship targets mainly employees to improve corporate identity and strengthen the corporate brand. The effect on employees can be both direct and indirect. Indirectly, the employees can be influenced by interacting with other people both from their work and social environment. Directly, a stronger commitment and identification with the company can be developed in a situation when an employee is interested in a sponsored event, team or personality. Therefore, the companies can benefit from the involvement of employees in a sponsorship choice and then in a sponsorship activity (Khan, Stanton & Rahman, 2013). Sponsorship also influences employees‘ perceived fit to the organization, their loyalty and pride in their organizational association (Zepf, 2008). Edwards (2016) suggests that sponsorship of high-profile sport events such as Olympic Games which suggests that such sponsorship boosts employee's sense of pride in the company, identification and perception of social responsible employer.

Methods

Data for this research were collected by means of an online questionnaire. 72 of the 85 respondents belonged to the target group: young graduates in economics in the age of 21-35 who are currently employed. The structure of target respondents was 50 % women and 50 % men who are currently employed and graduated in economics in bachelor or master studies. 7 % of them were in the age of 31-35 and remaining 93 % in the age of 21-30.

The respondents were asked on their attitude to sport, satisfaction with employer, whether their employer includes sport in the strategy, if they valuate it positively and there were several questions on employee loyalty. In the part on employee loyalty the respondents had to evaluate the statements given within the range 1-5, where number 1 means "strongly agree" and 5 "strongly disagree." The five-point scale that ranges the respondent's opinion was inspired by five-point Likert scale (Kim, Han & Park, 2001). Likert-scale instruments are most frequently used to measure psychological constructs (Nemoto & Beglar, 2014).

The questions on employee loyalty for this survey were created based on following assumptions. Loyalty is a psychological state and describes the relationship between an employee and an organization. Loyalty can be expressed through the belief in and identification with the company's values, goals and characteristics, desire to maintain member of the organization and aim to deliver high performance (Turkyilmaz, Akman, Ozkan & Pastuszak, 2011). The employer can try to make employees loyal by fulfilling their needs through providing them favorable working conditions.

As a result, an employer can gain positives like extra efforts from its employees, intention to stay, sense of belonging and willingness to take up more responsibility (Yee, Yeung, & Cheng, 2010).

For the research purposes three hypothesis related to employee loyalty were stated and tested through chi-square test of independency on a significance level of 5 %.

Results

The survey shows that young graduates in economics do sports. Only 8 % stated that they do not have any relation to sport. 10 % do sport mainly passively and 82 % actively. The young employees in 71 % claimed that their employer includes sport in the corporate strategy, mostly in the way of financial contribution for sport activities and providing MultiSport card (mentioned 38 times). After that respondents confirmed 27 times that the employer offers regular or occasional sporting activities, sport facility on a work place, etc. The employers act as sport sponsors in 16 cases. Most of the respondents perceive this activity as positive. 21 % of respondents are convinced that their employer does not provide sport related activities of this kind or are not aware about it, but in most cases, they think their relationship to the employer would improve if the company included sport in its strategy. When asking on the satisfaction with the employer, 58 % of answers described the complete satisfaction with no expectation to quit. 7 % of the respondents is about to quit soon, 16 % of the respondents do not want to stay longer in a job than next 12 months and 19 % plan to change the job in the period of 1 year or longer. 37 % of the employees that expressed their intention to leave the company stated that the reason is the discontent with the employer or both with the employer or job. Remaining 63 % wants to quit because of not liking their job (40 %), look for a change or new experience (6 %) or have personal issues like moving, coming back to the studies, etc. (17 %).

The Table 1 below illustrates the survey questions on loyalty and their evaluation by respondents within a range 1 (strongly agree) -5 (strongly disagree). The table shows the frequency of respondents' ranking.

Table 1. The questions on employee loyalty

	1	2	3	4	5
I IDENTIFY MYSELF WITH THE CULTURE AND VALUES OF THE EMPLOYER.	12	21	25	13	1
I VALUE POSITIVELY THE EMPLOYER'S APPROACH TO AND CARE FOR EMPLOYEES.	13	27	20	9	3
I WOULD RECOMMEND THE COMPANY TO A FRIEND WHEN LOOKING FOR A NEW JOB.	24	28	15	3	2
I AM PROUD TO SPECIFY MY EMPLOYER WHEN I MENTION MY PROFESSION.	27	19	20	3	3
I APPRECIATE MY EMPLOYER AND I DO NOT LIKE TO HEAR CRITICISM FROM OTHERS ON ITS ACCOUNT.	14	20	27	10	1
I AM WILLING TO MAKE PERSONAL CONCESSIONS IN THE INTEREST OF MY EMPLOYER.	3	16	24	23	6
I LIKE TO PARTICIPATE IN EVENTS AND ACTIVITIES ORGANIZED BY THE EMPLOYER (E.G. SOCIAL AND SPORTING EVENTS) ALSO OUTSIDE THE WORKING HOURS.	22	26	14	8	2

The Table 2 describes the respondents' evaluation of sport in employers' strategy.

Table 2. Questions on sport strategy evaluation

	1	2	3	4	5
I EVALUATE POSITIVELY THE ACTIVITY OF MY EMPLOYER FOCUSED ON SPORT.	22	13	11	5	0
I AM INTERESTED OR ACTIVE IN THE SPORTS ACTIVITIES OFFERED OR CARRIED OUT BY THE EMPLOYER.	17	7	13	7	7

Discussion

Three hypotheses were tested with results retrieved from the online questionnaire and findings can be implied on young employed graduates in economics.

To realize whether including sport in a corporate strategy affects the loyalty of employees, zero hypothesis named below was stated:

H_0: There is no association between the employee loyalty and sport involvement in a corporate strategy.

By testing this hypothesis, it is possible to realize whether the employees working for a company that does not include sport in its strategy show are the same loyal as employees who are confronted with sport in their company.

For chi-square testing the absolute frequencies of answers on loyalty were used for each group of respondents. The critical value for chosen significance level of 5 % is equal to 9.488. After comparing this with test value (12.382), the zero hypothesis is rejected and alternative hypothesis that claims, that a certain association between the employee loyalty and the sport involvement exists, is true.

The closer to number 1 each respondent's evaluation is, the more loyal he or she is. When comparing the average loyalty of employees working for a company that included the sport in sport strategy (2.37) to the company that did not (2.99), there is 0.62 points difference in the loyalty. Therefore, it is possible to assume that the sport helps to improve employee loyalty.

Valuating positively the sport in the corporate strategy by employees can be related to their attitude to sport. To investigate whether the employees who do sport actively or passively appreciate higher the employer sport activities another zero hypothesis was stated:

H_0: There is no association between an attitude to sport of the employees and their appreciation of the sport involvement in the corporate strategy.

The test value of the chi-square test is lower than critical value for significance level 5 %: $5.556 < 9.488$. Because of this zero hypotheses cannot be rejected. Based on this paper survey their attitude to sport does not play any role in appreciating company's sport involvement. The limitation for testing this hypothesis is the fact that young people are most likely to do sports actively or passively based on the survey. As a result of this, the number of respondents having no attitude to sport while working for a company including sport in its strategy is low.

Testing the third hypothesis should explain whether there is a relation between employees' satisfaction with the employer and their loyalty. The zero hypothesis was stated:

H_0: There is no association between the employee satisfaction and loyalty.

Chi-square test results are following. On 5 % significance level, the tested value is higher than critical value: 61.054 > 9.488. Therefore, the zero hypothesis is rejected and there is an alternative hypothesis indicating that there is an association between the employee satisfaction and loyalty, that is true.

The average loyalty of people satisfied with their employer is 2.11 and 2.88 of people who have reasons to quit their job on a range 1-5 where number one shows the highest loyalty. These numbers result in assumption that satisfied employees are more loyal.

Conclusion

The results of this research show that there are multiple ways of including sport in a corporate strategy in the Czech republic - mostly in the way of financial contribution for sport activities and providing MultiSport cards. In most cases employees evaluated it positively. This paper proves that there is an association between employee loyalty and including sport in a corporate strategy. This result can guide companies in decision making whether sport is the right tool to reduce the employee turnover. The survey was carried out on young graduates in economics who are employed in the Czech Republic. The survey did not prove whether the employees who do sports actively or passively appreciate higher the sport involvement in sport strategy than employees who have no attitude to sport. More than a half of respondents expressed satisfaction with the employer with no intention to leave the company. There was a hypothesis stated and confirmed that there is an association between employee satisfaction and employee loyalty. To enhance the loyalty the companies should aim to make their employees satisfied.

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ANALYSIS OF MANAGEMENT AND ORGANISATION OF ELITE SPORTS FROM THE VIEWPOINT OF SPLISS METHODOLOGY IN THE CZECH REPUBLIC

Nová Jana
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

In 2015 and 2016, the author conducted an audit of the Czech national elite sports policy using the international research methodology called SPLISS (Sports Policy Factors Leading to International Sporting Success). Based on the audit results in Pillar 2 entitled Management, Organization and Structure of Elite Sports, this paper analyses the situation regarding this area in the context of the Czech Republic. The analysis is complemented by an on-line questionnaire survey among 93 elite athletes and 20 elite trainers. The conclusions of the analysis are then used to formulate proposals to support a coordinated approach to elite sport management in the Czech Republic.

Key words: *Management of Elite Sport, Coordination of Strategies, Impact of Elite Athletes and Coaches on Elite Sport Policy*

Introduction

As international competition among countries in sports is becoming stronger and financial support for elite sport is increasing, national governing bodies in sport should focus on strategic approaches to develop world-class athletes. Considering this, it seems that the need to analyse the factors leading to international sports success is legitimate (De Bosscher, Shibli, Westerbeek, & Van Bottenburg, 2015). The concept of optimisation of management and organisation of elite sports on the national level and development of system tools for achievement of success in international competition in sport began to be investigated towards the end of the last century. This was in reaction to the growing competition in sport and the changing situation in disposable public resources, especially for sponsoring of elite sports, which were becoming professional. This area is covered by very few studies that would deal with international comparisons of management and organisation of elite sports. The only exception is represented by the project entitled "Sports Policy Factors Leading to International Sporting Success" (SPLISS), implemented in two stages in selected countries of the world. SPLISS is an acronym for factors of sports policy leading to international sporting success. The project was implemented by an international network of cooperation in research, which is involved in coordination, development and sharing of expertise in the area of innovations of high-output research into sports policy in cooperation with the authors of the policies, National Olympic Committees (NOC), international (sport) organisations and research entities all over the world. In 2008 the first joint project was developed to compare 6 countries in this area (www.SPLISS.net). Since 2009 the group developed a new international project partnered by subjects from 15 countries. The outcomes of this most innovative benchmarking were presented at a SPLISS conference in 2015 together with a book about the project SPLISS 2.0.

As mentioned by De Bosscher et al. (2015), international comparisons in the area of management and organisation of elite sports are difficult, for there are fundamental differences among the individual national systems of elite sport, their structure, organisation and anchoring in the political system. There is no consensus, neither among managers nor among academics, in the view of what is good practice in the area of development and implementation of management, organisation and structure of elite sport. Green (2009) emphasizes the inclination towards control and coordination in elite sports. Centralised as well as decentralised models of elite sport management in Nordic countries were described by Andersen and Ronglan (2012). The need for simplification and specification of clear competences of various bodies in the system of elite sport is also emphasized by Oakley and Green (2001). As for the involvement of stakeholders (including athletes themselves and their coaches) in development and evaluation of strategies for elite sport, there is little research in the area, although the relevance of this issue is pointed out by Thibault, Kihl and Babiak (2010). The only international comparative study for development and implementation of management, organisation and structure of elite sport is available under the SPLISS 2.0 project (De Bosscher et. al., 2015), whose results were contributed to by 15 countries of the world. As shown by the study results, the countries with a high level of success in elite sport in international comparison have:

– Sports associations on the national level employing managers specialising in continual support of elite athletes and their coaches as their full-time job.

– Managers responsible for dissemination of important information, provision of advisory service and accumulation and keeping of expert support information/ services on the central level.

– Countries with strong centralisation in the area of elite sport do not achieve such a big success as those which rather coordinate activities and cooperate with various partners.

– With regard to elite sport the most successful countries are those which coordinate activities and financial resources in connection with clearly defined commitments and results.

– Successful countries have their athletes and coaches significantly involved in evaluations of elite sport strategies and in decision-making processes on the level of national sports associations.

Generally all countries tend to subsidise sports with a potential of success in international elite sport, but the implemented international comparisons have also shown that Australia and the Netherlands have adopted a most integrated approach to development of strategies for elite sport. There is strong coordination on the national level, long-term planning and periodic evaluations of the strategies by athletes and their coaches. These tasks are sufficiently staffed.

Approaches of the other investigated countries to management and organisation of elite sport differ but certain strong points can still be identified, concerning for example coordination of activities on the municipal level (Denmark) or strategic planning (Japan, Switzerland). Stakeholder involvement is still problematic in Brazil, Northern Ireland and South Korea.

In countries called post-communist (and also including the Czech Republic) the study automatically expects state control over elite sports. This management system is however also applied in Spain, Australia and South Korea.

As for the management structures, the study has shown that successful countries only have a single national coordination body for definition of strategies for elite sport (The Australian Sport Commission; The Sport Canada; The Sports Ministry in France; the Consejo Superior de Deportes in Spain; The Korea Sport Council/Korea Olympic Committee). In other countries there are 2 or more institutions coordinating elite sport on the national level. Sometimes they only take the form of a separate department coordinating activities of various agencies and keeping record of all cash flows to elite sport, or makes agreements about task allocations (Flanders, Japan, Switzerland).

Strengthening of the coordination role and the decision-making processes is considered to be achieved by the merger of the National Olympic Committee and the Association of National Sports Associations (Switzerland, the Netherlands and South Korea).

The international comparison of the management structures in elite sport was the inspiration for the audit of the situation in the Czech Republic using the SPLISS methodology. Thus the purpose of our contribution is to draw attention to the theme of management and organisation of elite sport and emphasize selected examples of good practice especially of coordination and strategic approach adopted in different countries of the world involved in the SPLISS 2.0 project, at the same time using the SPLISS methodology for analysis of indicators of pillar 2 of the SPLISS methodology entitled Management, Organisation and Structure of Elite Sport in the Context of the Czech Republic. The analysis further uses results of our in-house survey in the form of an on line questionnaire distributed among elite athletes and their coaches.

The conclusions drawn on the basis of the analysis are then used for formulation of proposals for support of a strategic approach to management of elite sports in the Czech Republic.

Methods

The data was collected in a national context, employing two instruments. The SPLISS methodology (De Bosscher et al., 2008), in particular the evaluation of indicators of the 2nd pillar entitled Management, Organisation and Structure of Elite Sport through content analysis of available data and documents. An inventory of conditions and the status of management and organisation of elite sport in the Czech Republic consists of critical success factors and a qualitative approach – desk research and content analysis was applied in order to gather the relevant information with regard to the overall sport policy in this area.

The second instrument used was an on-line survey conducted among elite athletes and coaches and part of a standardized, officially translated and piloted questionnaire relevant to the topic of the study (SPLISS, Pillar 2) was used. Purposive sampling was employed following the SPLISS methodology (De Boscher et al. 2015) that led to the sample of elite athletes N=847; response rate 10.98% (n=93) and the sample of elite coaches N=168; response rate 11.9% (n=20). Data collection was realized during the winter of 2015/2016. The data from the on-line survey was analysed with the IBM SPSS Statistics (24.0) software.

The results of the abovementioned instruments allowed for the evaluation of the status of management and organisation of elite sport in the Czech Republic and served a as a base for comparison with other countries in order to identify the gaps and to propose sustainable measures that would support strategic approach to elite sport in Czech Republic.

Results

A. Sport Policy Inventory – Critical Success Factors SPLISS Pillar 2

SPLISS Pillar 2 is concerned with the organisation and structure of sport within nations. According to this pillar for nations to have a realistic chance of elite sporting success a strategic approach at governmental level and operational structural coherence for efficient allocation and utilization of resources for elite sport, are of the utmost importance. The athletes' and coaches' survey is complementary to the inventory performed by researchers. The results from the overall sport policy inventory of the conditions in the elite sport system in relation to SPLISS Pillar 2 are presented in the Table 1.

Table 1. Sport Policy Inventory – Critical Success Factors SPLISS Pillar 2

Critical Success Factors	Evaluation
Coordination of financial inputs (horizontal) and activities: expenditures and activities connected with elite port on the national level are centrally recorded and coordinated, therefore overlaps are excluded	There is no horizontal coordination of financial inputs and activities. There are separate mechanisms of fund allocation and implementation of activities for elite sport o he level of the relevant ministries and in the framework of the structure of country regions, towns and cities. Support for elite sport by these different organisational levels is neither recorded nor coordinated centrally and therefore overlaps may be expected.
Coordination of financial inputs (vertical) and activities: distribution of funds and management of activities connected with elite sport on the regional/country level: every major financial input of this type is recorded and coordinated on the national level	There is no vertical coordination of financial inputs and activities. Major financial inputs are not recorded and coordinated centrally. Their coordination on the national level is absent.
There is only a single organisation on the national level with exclusive responsibility for elite sport	In the Czech Republic there is no sgnle organisation with sole responsibility for elite sport. There is a dual system of responsibility for elite sport (the National Olympic Committee and the Czech Sport Union). The newly established National Sports Council has created positions of representatives for sport of the Ministry of Defence, Ministry of the Interior and Ministry of Education, Youth and Sport (MoE).
Elite sport is acknowledged as a valued part of the politician´s responsibility portfolio	There is no exclusive responsibility of any minister for elite sport.
There are documents of long-term planning of elite sport development, including the commitment to provide subsidies for elite sport and development of professional elite sports	
There are long-term policy plans (for 4-8 years at least) specific for elite sport, communicated publicly, evaluated periodically and funded	There is a long-term plan entitled "Concept of Support for Sports 2016-2025 – SPORT 2025" (hereinafter just Sport Concept 2025) defining orientation of development and support for Czech sport, pillars, priorities, strategic objectives and conditions of their fulfilment for the period 2016 – 2025, following previous strategic documents of the Ministry of Education, Youth and Sport (MoE) in the field of sport: Concept of State Support for Sport in the Czech Republic (2011), Plan of Support for Development of Sport in the Period 2015 – 2017 and the document of the Ministry of Health (MoH) entitled National Strategy of Health Protection and Support and Disease Prevention Health 2020 (2014). These concepts are available in MoE materials on the web site of the ministry. They are not communicated in any other way, apart from articles in mass media. The currently applied Concept of Sport Development approved in 2011 has not been evaluated periodically. Support for elite sport is provided through programmes of sport funding of the MoE for the current year.

The policy is periodically evaluated at the presence of athletes, coaches and performance managers who are officially invited	The questionnaire-based inquiry mentioned under B above proved significant areas for improvement in this area. The level of involvement of athletes was evaluated as insufficient and none by 41.7 % of the inquired athletes and 52.9 % of the coaches.
National sport associations receive subsidies for (at least) four-year periods	National sport associations only receive subsidies per calendar year.
National management bodies include athlete and coach representatives	Since 2016 there is a newly established National Sports Council as the advisory body for the Minister who chairs it. Council resolutions enjoy the status of recommendations. Every Council member has his allocated area of responsibility for which he submits his suggestions to the Council. He can also form a work group for the given area of other representatives of the sport environment. The new components of the Council also include the Regional Chamber (with representatives of the Association of Regions, the Union of Towns and Cities and the Association of Local Self-Governing Bodies) with the advisory role. The purpose of the National Sports Council is to address particular issues of the sports environment. Athletes and coaches are only represented by one Council member each with the decision-making powers.
Members of the advisory body of the national control authority are experts who decide about all matters of elite sport	Available information does no clearly reveal the nomination system of the National Sports Council. Its composition is published on the MoE web site.
There is an official objective benchmarking instrument used for evaluation of the criteria of financing of the national sports associations; the evaluations are performed by an independent organisation	There are official criteria of funding of national sports associations. There is the non-investment Programme of the MoE V – Sports Union Activities Sporting, organisational and content activities of unions are supported, including support for the headquarters. Activities connected with advance sport competitions are supported. Evaluation criteria The financial volume of state support is defined with regard to the membership base, the number of members of the MSF, the number of countries participating in the elite competitions, the tradition and social relevance in the Czech Republic, the structure of domestic competitions and economic demand of the sport. The section of sport and youth was subject to internal audits in 2015 on the basis of the Plan of Internal Audits for 2015 and requirements of the Minister. The audits focused on the subsidies in the area of state support for sport and programme financing of investment events in 2014 and 2015 and setting of the internal control systems. The audits found a number of faults in sum reducing quality of work of the Ministry of Education, Youth and Sport and transparency of sport funding. Measures were adopted on the basis of the audit for quality improvement of the process of state support for sport and programme financing of investment events in the area of sport.

There is an effective and accurate structure of decision-making in the area of elite sport policies	There is no effective and accurate structure of policy decision-making in elite sport. There is a system of consultations with bodies and institutions specified by the sport policy maker (usually MoE)
Athletes and coaches are well informed about national policy, support services and other aspects	Athletes and coaches are not informed well about national policy, support services and other aspects – see the results of the questionnaire inquiry

The used evaluation of the indicators of pillar 2 of the SPLISS methodology entitled Management, Organisation and Structure of Elite Sport allows for the conclusion that in the Czech Republic there is no unified approach to the policy formulation as there is no close coordination among all organisations engaged in elite sport, hence their tasks are ambiguously defined and various activities overlap.

B. Results of on line questionnaire inquiry questionnaire inquiry among elite athletes and their coaches

Responses obtained by on line questionnaire inquiry among elite athletes and coaches cover their opinions about political decisions and changes in elite sport policies, levels of communication of sport management bodies towards athletes and coaches and the levels of their involvement in development and subsequent evaluations of the elite sport policies after political plan implementation.

Opinions of Athletes

As follows from questionnaire inquiry only 7.5 % of the respondents – athletes reported that they were informed about political decisions and changes in elite sport policies. The question of general assessment of the level of communication of their club / national management authority / national sports association was answered by 61.3 % of the inquired athletes in terms of excellent or good, while 20.4 % saw it adequate and the rest of the respondents not good or poor. The question whether the national sports association has a committee of athletes as an officially acknowledged collective body representing athletes in front of the national control authority was answered yes by 19 % of the respondents, no by 42.9% of the respondents and 38.1 % did not know. The general level of involvement of elite athletes in preparation of the national elite sport policy, i.e. involvement in policy preparation on the level of the national sports association in the stage before its formulation in writing and publication was seen as high by only 1.3 % of the respondents, sufficient by 16.5 %, insufficient or no-existent by 39.3 % and 43 % of the respondents did not know. Evaluation of the organisations making the national sports policy was similar but the percentage of respondents who did not know the answer was higher, up to 48 %. The level of general involvement of elite athletes in evaluation of elite sport policy after implementation of the policy plans for their sport was seen high and sufficient by only 3.8 % of the respondents, adequate by 13.9 % and insufficient or none by 41.7 %, while the rest of the respondents were not sure. Evaluation of the organisations making the national sports policy was similar. As concerned assessment of organisation and structure of elite sport we asked the athletes which organisations have positively contributed to their sport success as elite athletes to date and to what extent. The best scores were achieved by the athletes´ own sports clubs, whose contribution was seen by 27 % of the respondents as very high, by 28.4 % of the respondents as relatively high and by 29.7% as adequate. Contributions of the national sport management bodies, sports associations, the national Olympic Committee and the government were rather classified as adequate, relatively low and very low.

Their answers to the question whether, in their opinion, the status of elite athlete was connected with excessive paperwork, revealed that this issue was not important for elite athletes. Only 14 % of them agreed that the paperwork was extensive, 33 % did not agree with the statement, 41% were indifferent and 11% were unable to judge the administrative load.

Considering policy making there are interesting answers to the question whether sport policy makers regularly consult athletes´ specific needs. Most athletes (70 %) mentioned negative experience, 20 % could not take any standpoint and 10 % were indifferent.

As concerned evaluation of the current situation in elite sport in their country with regard to performance on the top international level in comparison to other countries only 44% of the respondents saw the performance adequate and sufficient and nearly 47.4 % of them assessed the performance as inadequate or very insufficient.

Opinions of Coaches

As followed from the questionnaire-based inquiry about political decisions and policy changes in elite sport only 5.3 % of the inquired coaches reported to be informed. The question whether their national sports association had a commission of coaches as an officially acknowledged collective body representing coaches in relation to the national control authority was answered in positive by 57.9 % of the respondents. The answers to the question about the extent to which elite coaches generally contribute in the area of their sport and in their country to preparation of the national policy in the elite sport area, before its written formulation and publication, revealed critical situation here when 41.2% of the respondents saw the level of their involvement in their sport in relation to their national control authority as insufficient or none and 41.2 % were unable to judge. Similarly 52.9 % of the respondents saw the level of their involvement in the national elite sport policy preparation in relation to organisations making national sport policies as insufficient or none. That is like the athletes the coaches too saw their level of involvement in the national elite sport policy preparation as rather insufficient or none and a great number of them were not sure. Elite coaches also expressed negative answers to the question of the level of their general involvement in elite sport policy evaluations after implementation of the policy plans, 53% of them considering their involvement insufficient or none. The same applied to the assessment of the organisations making the national sport policy and the national control bodies for their sport. In the context of evaluation of the level of paperwork connected with the status of elite coach 71 % of the respondents agreed with the load being excessively high. The question whether policy makers regularly consulted the coaches to find their specific needs was only answered in positive by mere 18 % of the respondents, 24 % expressing absolute disagreement and 24 % being unable to tell.

Discussion

Evaluation of the situation in the area of elite sport in the Czech Republic on the basis of data obtained by inventory of the indicators of pillar 2 entitled Management, Organisation and Structure of Elite Sport and from the implemented on line questionnaire inquiry with the respondents recruited from among elite athletes and their coaches, can be summarised in the following conclusions:

– The Czech Republic has no working policy on the national, regional or local level for elite sport development. This area is only addressed by the overall Concept of Support for Sports 2016-2025 – SPORT 2025" (hereinafter Sport 2025 Concept), defining orientation of development and support for Czech sport, pillars, priorities, strategic objectives and conditions of their fulfilment. Elite sport is generally covered by area 7 of the Concept entitled Competitiveness of Sport Representation of the Czech Republic.

– There is no nationally coordinated policy for elite sport.

– Involvement of athletes and coaches in elite sport policy making and evaluation is unsatisfactory and limited.

– There is no systematic cooperation and networking, communication and partnership between various target and interest groups in the elite sport area (athletes, public administrative authorities, the business sector, the sector of education, sports organisations and sports bodies).

– There is remarkable absence of established programmes for elite athletes on the national level. The only exception is represented by the project of the Czech Olympic

Committee "Top Team", preparing this programme in 2017 to support preparation of talented future medal winners not only for the Winter Olympic Games at Pchjongjang but also for the following years and other competitions. The project provides finance for preparation including complex background such as medical and scientific care on the top possible level.

– There is no system for monitoring and evaluation of programmes for support of elite sport and elite athletes.

– There is remarkable absence of both horizontal and vertical coordination of provision of sustainable financial support to elite sport.

– There are no transparent rules for binding funding to performance.

– There are insufficient human resources for organisational development of elite sport on the level of national control authorities and national sport associations.

The above described situation, in our opinion, indicates the need for organisational and professional standardisation and professional management of elite sport on the basis of theoretical professional concepts. There are two levels of professional approach, professional sport and professional organisation of sport. Evetts (2009) offers two types of expertise in knowledge-based work: subject professionalism and organisational professionalism. The former is based on professional values shared by the profession, competences in the area of education, professional preparation and apprenticeship and socialisation, sometimes guaranteed by licence, while the latter springs from managerial hierarchies, standardised procedures, objective setting, performance surveys, responsibility and control. In the area of sport there is the continuing requirement for effective and responsible management of sport organisations which may be seen as commercialised professionalism or organisational professionalism (Hanlon, 1998). Robinson and Palmer (2011) mention internal and external factors of professionalism of sport organisations. The internal factors are related to the needs and expectations of the members and other stakeholders of the given sport organisation. The external factors are connected with governmental legislation, expectations of sport funders and responsibilities of the sport organisation in the area of its activity. In the case of sports associations and national control authorities the area of responsibility also includes professional management of elite sport. Presence of competent experts in these sport organisations recognising the values of the profession may facilitate achievement of organisational professionalism in the area of elite sport management. To maintain various levels of organisational professionalism based on the hierarchical structure of sport (the sport model of EU) the sport organisation must employ professionals in elite sport management and follow the philosophy of professional hierarchy (international federations – national federations – regional and local sports clubs). This also requires development of strategies, policies and procedures in the area of management and HR management – especially creation of positions for elite sport management, recruitment and selection of employees and specification of performance criteria for their work.

Conclusions

The results of our analysis show that the area of elite sport management and organisation in the Czech Republic is in the focus of attention of both the responsible central state administrative body on the one side and the national Olympic committee, the national sports associations and regional and local administrative authorities on the other. But activities of these bodies are isolated and short-term and lack horizontal, vertical and regional links. Hence our below basic recommendations for implementation of sustainable measures to support strategic approach to elite sport are based on the findings from our study considering the situation in countries which may be considered examples of good practice in management and organisation of elite sport:

– Creation and adoption of a national policy for elite sport reflecting recommendations of international studies in this area.

– Adoption of systemic measures addressing elite sport area (evidence – based policy) and replacement of fragmented activities with coordination.

– Establishment of an independent national institution to address elite sport issues, to propose and implement activities for elite sport support and performance enhancement and activities for coordination and improved communication and cooperation among stakeholders in the area of elite sport.

– Introduction of positions of elite sport advisers within the sport structures (national sport management bodies and sport associations) and their professional standard building.

– Proposals and implementation of targeted programmes for support of elite sport and sport performance.

– Data collection in connection with elite sport and implementation of a monitoring system for evaluation of effectiveness of policies, programmes and services in elite sport.

– Support for research and projects in the area of elite sport organisation and management.

– Support for formal agreements between the national sports associations and sport organisations, educational institutions and other commercial entities for creation of appropriate conditions for elite sport.

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LEAVING COMPETITIVE SPORT IN THE CZECH CONTEXT

Svobodová Zora, Nykodým Jiří, Stará Alena, Válková Hana, Večeřa Karel
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: What happens to athletes when they end their active participation in the top-level competition?

This contribution focuses on career transition as a phase of a breakthrough in professional development. Successful handling of transitions, both within and outside the sport, allows a greater opportunity for athletes to live a long and successful life in sport as well as the ability to effectively adapt to post-career.

An unmanaged or unmanageable involution brings about personal problems of a different character making up for the athlete's loss of a social economic, psychosocial, and economic capital including loss of sport environment experience for the next generations

Methods: The group watched the top athletes from various sports (football, hockey, basketball, volleyball, athletics, swimming) and consists of 71 women and men. Reported athletes are former (already inactive) and active athletes from national top competitions in the Czech Republic. The means of collecting data was a semi-structured interview in which we formulated thematic areas on the development and course of sports careers, family backgrounds, life or sports links, lifestyle, needs, goals and ability to solve problems related to sports career and involution. Data analysis was performed using categorical data sorting followed on by an observation of categorical clusters, and the development and trajectory of an individual athlete's life story.

Results: In the Czech Republic still lacks a systematic strategy at national, regional or local level in the field of dual careers. There is only the Dual Career Program of the Olympic Committee for Olympians, services for other athletes are still missing.

Conclusion: The aim of research itself is to define psycho-social variables – categories in connection with managed or unmanaged involution in the stage of sports career termination and transfer to everyday life. On the base of processing the results of our research we created consequently an education programme for former and active athletes, trainers, sports assistants and managers, sports coaches. We will also offer this programme to clubs in different sports, to subjects giving coach licences and the results will be also included into FSS´s studies programme – sport coaching and management.

***Key words**: athletic career, transition, socio-cultural context.*

Introduction

Leaving competitive sports, unplanned or unmanaged involution often brings personal problems of various characters causing athlete´s loss of social, economic and psycho-social capital, including loss of sports environment experience for future generations.

Researches indicate that numerous athletes are poorly prepared for retirement from competitiveness and they can face significant difficulties while managing life changes that join the end of their sports career and identity. Early studies included generally well published negative or even traumatic experience of athletes who retired from elite sports (Mihovilovic, 1968). Other studies also noted traumatic effects on termination athletic career, including alcohol and misuse of narcotic drugs, acute depression, eating disorders, identity confusion, low self-esteem and attempted suicide (Park et al., 2013, Blinde & Stratta, 1992; Ogilvie, 1987; Sinclair & Orlick, 1993; Svoboda & Vanek, 1982).

In the field of sports psychology, the conception of transition was introduced in 1970s and 1980s and consisted in the fact, how athletes cope with retirement from highly competitive and professional sports (Cummins & O'Boyle, 2015, Schlossberg, 2011, Haerle, 1975; Hallden, 1965; Mihovilovic, 1968). Since then, the research has been focused on different phases: the end of athletic career was originally considered as a unique event. However, researchers re-evaluated again the termination of athletic career as a transitional process.

The term "transition" was connected with various themes in last decades. Research conducted thus far speaks about development of an individual life, professional planning, social support and processes of ageing, retirement and dying. As a general principle, transition is connected with the occurrence of one or more specific events that bring not only „the change of presumptions about oneself" in an individual (Schlossberg, 1981), but also social misbalance (Wapner & Craig-Bay, 1992), which is above the everyday life changes in process. (Sharf, 1997). The end of career may happen in every athlete´s life stage. An increased attention is payed to the termination of top athletes´ career whose lives are completely involved in sports. The process of career termination for this group can be then especially difficult and disruptive, given their age, revenues and ego as well (Baillie & Danish, 1992).

Theoretical frameworks of sports career termination

Initially, most theorists applied general models trying then to apply them on the field of sport and explain the process of career termination with their use. However, theoretical frameworks with specific sports requirements were later designed (Gordon & Lavallee, 2012). These were derived from thanatology, scientific studies of dying and death. Community of sports psychologists suggested that several thanatological studies have a link to sports career, in particular to issues of injuries at sport and career termination. Another theoretical frame is social gerontology, the study of aspects of aging. The concepts of social death serve in such a case as a model for clarifying social and psychological changes linked to sports retirement. At later stage, the theory of transition, that is a theory of career transitions, was defined. It was introduced into the field of sports psychology in 1970s and 1980s. It pursues how athletes cope with the retirement from highly competitive and professional sports (Haerle, 1975; Hallden, 1965; Mihovilovic, 1968).

In following research, the way how to identify different stages of the transition process consisted in the fact how talented individualities developed in the field of science, art and sport (Bloom, 1985). This way of talent´s development in sports included a) opening stage when young athletes are presented in an organised sport and practising it, they are identified as talented ones; b) evolution stage during which athletes focus more on sport and the volume of training and level of specialisation are increasing and c) championship or excellence level on which athletes reach the highest level of athletic eligibility. Stambulova (1994, 2000) created a stage model based on her research on career transition of Russian athletes. Stambulova divided athletic career into predictable stages and transitions that include (a) beginning of a sport specialisation, (b) transition to an intensive training of chosen sport, (c) transition to highly performed sports and adult sports, d) transition from amateur sports to professional sports, (e) transition from peak to the end of sport career and (f) termination of a sports career.

In our country, the theory of transition is also known as „the evolution of incentive structure" throughout lifelong sport career. It was Miroslav Vaněk, Czech professor of sports psychology, who came up with this idea of incentive phases and transition stages in 1960s.

Provided the theory of transition, Nancy Schlossberg (1981) defines this transition as an event leading to the change of various presumptions and asking adequate changes in an athlete behaviour and his relationships. She identifies in a model of adaptation to transition three main groups of factors that influence the process of transition, namely characteristics of athlete experiencing transition, athlete´s perception of career transition and characteristics of environment in which athlete appears before and after career transition.

In our contribution, we pursue categories, psycho-social determinants linked to retirement, handling with these factors, perceived quality and long-term consequences of transition for athletes in the Czech Republic.

Methods

In this qualitative study we evaluate the pension process of Czech athletes preparation for it. Our goal is to name the categories, the psycho-social determinants we identified on the basis of interviews and which influence the process of involution and the inclusion of athletes in another career.

The principal of a theoretical framework of our study is the theory of transition, that is theory of career transition. A qualitative research was conducted and a method of enshrined theory was used to reach the aim of study realized in 2016, 2017. We asked athletes (N-71) about their life and sport story in semi-structured interviews with questions – thematic headings. The set under examination is composed with active and minimally 5 years inactive athletes playing one of chosen team sports (football, hockey, basketball, volleyball) as so as individual sports (athletics, gymnastics and swimming) in the top-level competitions of these sports in the Czech Republic or taking part in representative, Olympic selections and having a professional contract.

The way the athletes were selected and then addressed was an important part of our research. The familiarity principle was used in this phase. That means that the persons addressing the selected athletes and later on making interviews were people with credit in the given sport – former playes, coaches, and as such they were trustworthy and more acceptable for our sampled athletes (cf. a snowball sampling).

The data analysis process in anchored theory is already in the same phase as its collection (Strauss & Corbin, 1999). The phase of so-called open coding or the concept-making phase followed (Řiháček & Hytych, 2013). This is the first conceptualization of the data, which identifies meaning units that are categorized according to their importance into clusters or groups, categories (Miovský, 2006; Strauss & Corbin, 1999; Willig, 2001).

The thematic analyse was made on the base of qualitative data comparing an individual way of solution for (a) sports career, (b) strategy of career termination, (c) relation framework, (b) own identity – introspection, (c) partnership and motherhood, (d) economic reality, (e) dual career (Svobodová & Válková, 2017).

Athletes participating on the study were contacted in a familiar way. They were informed about the purpose of study and four experienced questioners realised meetings at chosen place. The interviews were recorded (taking from 45 to 60 minutes) and then literally rewritten. At the beginning of meetings, athletes were acquainted with the rules of getting involved in the research (anonymity, security of personal data) and with the possibility to contact the team of researchers for further feedback or consultancy, if desirable.

Results

On the base of thorough research it was found that the strategy of building dual career in the Czech Republic was not defined earlier than in 2014 via project COC with support of Ministry of Education, Youth and Sports (http://www.olympic.cz/text/dual-career). It means that a strategy for dual careers on national, regional or local level has been missing so far. As the project begins, the systematic cooperation and development of relationships on all levels is still building. Specifically formulated programmes for dual careers and services for athletes are still missing (Nová, 2016).

The result of our research survey is described in categories that reflect themes or processes in all 4 stages of sports career (Wylleman et.al., 1999, Svoboda, B., & Vanek, M., 1982). The first stage of sports career is called early sport socialisation - early specialisation, generation transmission, joy of movement, changing of sports are typical for the stage of early sports beginnings.

In the second stage - early intervention we defined category of getting older or progressive career building, crucial crossings in life as well as in sport emerge in a career.

The stage of stabilisation means the peak of many athletes´ personal fulfilment, besides joy of sport, it is also performance, fame, money, self-identification only with sports environment, sports or life crossings, injuries, introspection. The first references to the strategy of career termination, relationship field, engagements abroad, partnership, motherhood appear in this stage.

The last stage of sports career is involution. In this article we dealt with the categories that are most often appearing and in what amounts. It this stage, the importance of the strategy how to end career and consequently how the career was ended in reality (planned/unplanned) increases. We defined also categories of late introspection, relationship field, handling with the change of financial reward, conflicts between expectation and real evaluation in society.

To collect these data we addressed 71 athletes, 28 women and 43 men, 16 Olympians, 44 athletes represented the Czech Republic, the others took part at least in the top-level competitions of given sport in the Czech Republic.

We observed the most categories linked to involution and influencing the fact if an athlete manages or not transition from sport to another career, i.e. education. In our group, there are 45% athletes having university degree, 35% out of them having secondary education diploma called „maturita“ and 20% out of them having lower secondary education. Regarding the academic profile in Spain, most of the athletes had completed the preparatory courses for the university (39.3%), they were studying in higher education (39.5%) (Lopez de Subijana et.al., 2015).

31% out of athletes have already chosen the strategy for the end of their career, majority stayed in sport as trainers, managers, scouts, 69% athletes ended sport career without strategy, not solving its termination and relying on the help of others, coincidence etc. We found out in category „were you consulted, advised about the end of career“ that 35% athletes consulted involution with nobody, 14% out of them did it with the coach/manager and 51% out of them with family members, partners.

Help of clubs, unions in all sports, apart from swimming, is very insufficient – only in 14% cases, the club or union were interested in help for athletes to manage involution, being involved in other job. In this case, 2 noted clubs were foreign ones, that is only in 8 cases a club helped athletes.

The reasons of career termination were following: 58% athletes ended career suddenly, without preparation (injury, health, loss of performance, lack of club´s interest). For these athletes, the process of transition was more demanding mentally, socially and financially than for the ones with a plan – strategy of involution.

Women athletes ended career because of planned or unplanned motherhood in 72% cases, 18% out of them because of the loss of interest in elite sport and 3 out of them ended career suddenly (injury, health).

Discussion

This study examines process of transition in elite sport. It focuses on main aspects of involution process, reasons, way and other circumstances solved by athletes in the stage of career termination. Our aim was to find out categories resulting from personal confession of athletes that can help us to understand and map better the process of involution, what the athletes live and how they move through this stage. The approach to involution solving is individual, however, some categories are repeated in interviews and we can consider them as the base to create an educational programme of sports career for athletes, trainers.

In comparison of our results with literature (Cummins & O'Boyle, 2015, Gordon & Lavallee, 2012, Stambulova, 2012) we can conclude what follows: a) career termination is due to more sources, it should result from a longer process of thinking and decision making b) although career termination can cause stress, there are significant differences of individuals´ reactions, c) voluntary retirement contributes to smoother transition process, d) early life plan after the career termination helps very much to manage involution and to build new life, e) solving process depends on causes, athlete´s personality and level of his relationship framework. Promotion of education, workshops about eligibility and setting goals can help athletes with healthy adaptation. It was also proven that approximately 15-20% retired top athletes experience transition (Alfermann, 2000) and need psychological advice.

Our results also confirm that athletes preparing themselves for sports retirement and for managing of „non-sports role“ with the use of family background are affected by transition from sport more smoothly, the support of clubs in the Czech Republic being absolutely insufficient at this point of time (Bokůvka et.al., 2017).

Conclusion

The aim of research "Athlete´s life after sport career termination I and II" is to map theoretical basis and research on experiencing involution and its way of solution conducted so far. The aim of research itself is to define psycho-social variables – categories in connection with managed or unmanaged involution in the stage of sports career termination and transfer to everyday life. On the base of processing the results of our research we created consequently an education programme for former and active athletes, trainers, sports assistants and managers, sports coaches. Programme "Mentor of sports career" will feature topics: relation to the involution phase the concept of "dual career", factors of the daily life of an athlete in the stage of a senior career, factors of the athlete's daily life at the stage of involution motivation, attitudes and their changes, value orientation in the sport environment individual responsibility and management of sports clubs, position of "mentor of sports career" etc. We will also offer this programme to clubs in different sports, to subjects giving coach licences and the results will be also included into FSpS´s studies programme – sport coaching and management.

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PERCEPTION OF STAKEHOLDERS IN NON-PROFIT SPORT ORGANIZATIONS

Tripes Stanislav
University of Economics, Prague, Faculty of management, Czech Republic

Abstract

Purpose: The purpose of this qualitative research is to identify important stakeholder groups in the Czech sport environment as perceived by managers of non-profit sport clubs. Managers are usually enthusiastic sportsmen who lack a managerial education and knowledge of stakeholder management theory. The goal of this paper is to investigate how managers perceive stakeholders and how they work with them within the strategy formulation and implementation.

Methods: The research sample was composed of eleven managers who were selected by cluster analysis from the previous quantitative part of the research. The non-profit sport organizations in the research sample have a different purpose and offer different sports at all competitive levels. The phenomenology approach was chosen for the qualitative research. The data were collected using semi-structured interviews and transcribed verbatim. The data analysis was based on open coding; three levels of codes were created. The presentation of results was based on a model of stakeholder prioritization – power, legitimacy and urgency attributes.

Results: Managers perceive stakeholder management differently, as most of them do not analyse stakeholders' requirements regularly, systematically and do not use some of stakeholder analysis approaches. Some of them perceive stakeholders as an insignificant part of management activities. Nevertheless, the deep analysis of stakeholder groups identified parents of youth sportsmen as the main stakeholder group which are definitive stakeholders for most clubs. Parents often perceive sport clubs as a cheap kind of babysitting. The competitive clubs are perceived not within the same kind of sport, but in other sport clubs offering different sport clubs. The competitive fight is in gaining members or in acquiring funds. The main competitive advantage is perceived by internal stakeholders – the staff and trainers who built the club atmosphere.

Conclusion: The results present interesting knowledge about stakeholder management in non-profit sport organizations. This knowledge can be used not only for sport management education, but also for managers in praxis, how to manage relationships with stakeholders within strategy formulation and implementation.

***Key words**: Stakeholders, competitors, strategy formulation*

Introduction

The stakeholders of non-profit sport organizations play an important role because there is a close connection to the organizations' purpose, goals, strategy and overall performance (Freeman, 2010). The stakeholders operate in the organizations' macro and micro environment and have different goals, roles and responsibilities (Sotiriadou, 2009), affecting the organization or are influenced by the organization (Baker & Esherick, 2013). To determine who the stakeholders of an organisation are and what influence they have, the manager should carry out an environmental scanning.

The definition of the term "stakeholder" has gone through a long development, there was a lot of definitions resulting in the basic definition of "What and who really counts?" (Mitchell, Agle, & Wood, 1997). Freeman defined stakeholders as "any group or individual who can affect by the achievement of organization's objectives" (Freeman, 2010, p. 25). Another view is offered by Clarkson (1995, p. 109), saying "primary stakeholders are those who are needed for organizational survival, whereas secondary stakeholders are those who are not directly engaged in transaction with the organization and are not essential for its survival". Stakeholders can be considered from the environment point of view as internal and external stakeholders. For example, Hill and Jones (2012, p. 379) define them as: "Stakeholders are individuals or groups with an interest, claim, or stake in the company, in what it does, and in how well it performs. Internal stakeholders are stockholders, employees, including executive officers, other managers, and board members. External stakeholders are all other individuals and groups that have some claim on the company." The definitions presented are different in peculiarities. Stakeholders are divided into primary and secondary or internal and external. It is necessary to say that some external stakeholders can be considered to be primary stakeholders because of their importance, whereas internal stakeholders can be secondary like some group of staff, for example.

Each sport organization has its own stakeholders. There are a lot of stakeholders within the sports industry and describing groups is not easy due to the different types of sport organizations (Baker & Esherick, 2013; Byers, Slack, & Parent, 2012). Four main stakeholder groups were identified in the sport environment: government, sport organizations, community and media (Hautbois, Parent, & Séguin, 2012; M. M. Parent, 2008). By enhancing this concept, it is possible to consider an organization's board, members and volunteers, parents and others connected to the organization as belonging to the community (Robinson & Palmer, 2011). Each stakeholder group has different requirements, needs or goals which are regarded within stakeholders activities (Friedman, Parent, & Mason, 2004). The higher level of stakeholder problems is the heterogeneity of stakeholders within one stakeholder group. Each person has different experiences, attitudes, behaviour and opinions which causes heterogeneity (Walley, 2013; Windsor, 2010). Managers should pay attention to the changes in attitudes and behaviour of stakeholders. The following paragraphs will briefly introduce the requirements of stakeholder groups which should be reflected in the mission, vision and goals of an organization (Lussier & Kimball, 2014).

Considering the opposite order as stakeholder groups have been mentioned by Parent, the media as a stakeholder of NPSOs does not play such a significant role in the Czech Republic. The media are usually focused on high performance sports. Media as a stakeholder can be considered in the case of small local newspapers which are interested in local events, but not often about the activities of some club. The focus group of this media is the local community, which brings strong a influence and includes stakeholders like customers, owners, staff, sponsors, competitors, suppliers or other community groups (Filo, Cuskelly, & Wicker, 2015; Robinson & Palmer, 2011). The important group of stakeholders for non-profit sport organizations are sponsors, (MARQUES MIRAGAIA, FERREIRA, & CARREIRA, 2014) due to decreasing subsidies and lack of finances. Other sport organizations like suppliers, competitors and governing bodies, its behaviour and influences are described within the environmental analyses.

One of the most important stakeholder groups for NPSO is internal stakeholders, especially its members and ensuring they are satisfied. Factors affecting their satisfaction are team identification, services and communication. Members want to be perceived as a part of the NPSO and fulfil their desires and purposes of participation through some sport activity. Members are not only the athletes, but usually their parents in youth sports or other supporters (Beech & Chadwick, 2013; Byers et al., 2012). NPSOs are usually managed by elected representatives from all members (Durdová, 2012). Paid managers can hold management positions as well; the professionalization of management is connected to a span of activities and the level of stakeholders requirements (Beech & Chadwick, 2013) and it helps influence the overall performance of the club and the satisfaction of its members. An analysis of stakeholder behaviour and ascertaining feedback is necessary for strategic activities. Strategy formulation is based on key stakeholder requirements and its satisfaction (Friedman et al., 2004). Managers of NPSOs should be able to negotiate and work not only with the members and staff, but also with all stakeholders.

Identification of the most important stakeholders is discussed in sport organizations very often (Ackermann & Eden, 2011; Agle, Mitchell, & Sonnenfeld, 1999; Freeman, 2010; Hautbois et al., 2012; MARQUES MIRAGAIA et al., 2014; M. Parent & Deephouse, 2007). Management teams are interested in who the stakeholders are and how they want to cooperate or not with the organization during this time. This task seems to be difficult and manipulative for managers (Ackermann & Eden, 2011) due the different goals of a particular stakeholder. Managers should pay attention to their behaviour towards all stakeholders. Stakeholder analysis helps to distribute the effort of the organization between stakeholders to achieve the lowest costs and highest benefits at the same time (Walley, 2013). Usually there are three approaches to researching stakeholders: a descriptive (empirical) approach, an instrumental approach and a normative approach (Donaldson & Preston, 1995). The most used approach is the descriptive one, which analyses the organizational environment and describes all the stakeholders.

Methods

The research sample was comprised of eleven managers who were selected from the previous quantitative part of the research. The 21 NGBs under the Czech Sport Association were selected for the first phase of research and all clubs were asked to to fill out an expanive questionnaire focused on their perception of strategy. The non-profit sport organizations in the research sample have different purposes (youth, performance sport or sport for all) and offer different sports at all competition levels. The quantitative data were clustered and 11 managers for the semi structured interview were selected from the four clusters. The interviews were carried out in person at the managers' office subsequently transcribed verbatim. The qualitative data analysis was based on open coding and three levels of codes were created. The qualitative data analysis was performed using the software NVivo 11. The presentation of the results was based on Mitchells' et al. model of stakeholder prioritization (Mitchell et al., 1997), which is based on three attributes: power, legitimacy and urgency. These attributes reflects stakeholder salience – "the degree to which managers give the priority to competing stakeholder claims" (Mitchell et al., 1997, p. 854). The salience of stakeholders is based on the managers' perception of the above-mentioned attributes, which means other managers can perceive some stakeholder to be more salient than others (Agle et al., 1999). The concept of attributes considers that stakeholders can utilize one, two or all three attributes at the same time. The strength and combination of attributes forms stakeholders salience and according to this a manager could identify 8 groups of stakeholders and work with them (Walley, 2013). The above-mentioned attributes can be considered and explained differently. The following paragraph introduces Mitchells' et al. point of view.

Power is based on the thought that one subject has the power to make another subject do something, but this power can be acquired and lost over time. Stakeholders use this power for achieving their requirements and influencing events within the organization (Hautbois et al., 2012; M. Parent & Deephouse, 2007). Legitimacy is “a generalized perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions” (Mitchell et al., 1997). It is necessary to consider stakeholder groups and their behaviour over time, as the dynamics bring a sense of urgency to this model. This urgency is defined as a level of stakeholder requirements to be in immediate attention. Some stakeholder groups can pressure the organization for preferential treatment, but the situation can change during the strategy period. Stakeholders can move from one group to different groups within a really short period of time. The movement of one stakeholder can cause the reaction of one or more stakeholders which can lead to devastating consequences (Ackermann & Eden, 2011). Managers should be able to recognise these changes and be able to react to them (Windsor, 2010). The dynamic is represented by urgency in conjunction with power and legitimacy (Mitchell et al., 1997).

Results

The research has identified several stakeholder groups perceived by managers of NPSOs. Several stakeholder groups were introduced in the literature review but not all of them plays such an important role. Managers mentioned mostly parents, members, competition, staff, local government, governing bodies, sponsors, media, potential members and other stakeholders. This order of stakeholders was composed from the count of references within the coding and will be used for interpreting the results.

Parents are the main important stakeholder group. Their importance is based on the membership base of clubs – a high rate of youth members. Nevertheless, parents are still perceived differently, with the two main groups being represented – the parents who are closely connected to the club and those who are not and drive benefits from the club as a cheap babysitting service. Both groups of parents are willing and able to pay the membership fees, but the willingness increase with the personal relationship of parent to the sport or a club. Very often, these parents become members of the clubs as well, participate in practices or camps. Children perceive it as a good motivation to have better performance than their parents. The non-member parents within the first group usually have a very friendly relationship to the staff and are very helpful during some competitions etc. The second group of parents perceive the club as a babysitting service and their children are usually members of more clubs. These children are over trained very often or do not attend all trainings of the club. In the case of overlapping practices, parents prefer the more expensive one. These characteristics are perceived differently for the above-mentioned groups of parents, but t managers face the following factors in both groups.

Communication with parents is influenced by channels, people, needs and requirements of both sides of the communication process. This communication is via email, website or Facebook, but more often is personal when parents put off and pick their children up at the practice. Some parents stay at the facility during the whole practice and discuss some problems with the coaches. The topics are usually about the sport activity (apologies, the technique of motion, necessary material and its prices, etc.). Problematic communication arises during family time (birthday parties, holidays, etc.) which are in the same date and time of training or competition. Managers perceive ambitious parents as the main problem of their coaches' work. These parents disturb the coaches when working with some recommendations for improving the practices etc. These people are usually without a sport education, skills or results and wold only like to have successful children. They are pressed to train more and became over trained. Nevertheless, the coaches are perceived by parents as being very friendly, knowledgeable and erudite people. This is the reason why communication with parents is usually decentralised to the coaches and the feedback comes directly to the coaches. The social cohesion of staff and parents are strengthened by social events like the annual best sportsmen ceremony, parties etc. The good atmosphere and quality of staff serves as the tool of Word of Mouth Marketing and it is easier to gain new members.

Members are the second often mentioned group of stakeholders and can be divided into two subgroups – youth and adult sportsmen. Both subgroups have different requirements and behaviour making it important to communicate with them differently. The youth participation is closely connected to their friends and practices must by funny for them. Coaches should communicate with them carefully, although it is difficult. Children have problems with their attention span and do not behave according to their coaches' instruction, do not excuse themselves for absences etc.. The goal of the coach is not only preparing fun training sessions, but also building up group cohesion, developing and bringing up the youth not only in sport, but also in their personal lives. This can help decrease the fluctuation which is often caused by unsatisfied members. The loss of members is also caused by a lack of motivation or moving to a secondary school. The adult members do not fluctuate the same as children do. They have their personal goals – play the sport for a performance or just for fun. They are not willing to participate in club management activities or to be a coach. Club management tries to motivate them by decreasing membership fees but it does not work. Adult members prefer friendly informal communication without worries and duties. The managers perceive the importance of building loyalty and good atmosphere through open communication, social events, corporate identity and group cohesion. The result of their effort is that members are not only teammates but also personal friends.

Competition is perceived from three points of view – in gaining members, gaining sponsors and facility occupancy. Gaining new members and maintaining them is the most frequently discussed problem. Competition is perceived especially within different kinds of sports in the outskirts of the club. Young people have several more sport possibilities than they had years ago and competition has increased. Popular team sports, less technical oriented or sports which are possible to do it in early childhood (like football) have some advantages. Sports like volleyball usually start gaining members around the age of 12 and it is perceived that the more skilful are playing another sport. Nevertheless, there is a friendly atmosphere and managers are open to letting some children play another sport. The reason is that managers are happy that the child does some sport activity. On the other hand, performance oriented clubs perceived the competition within their sport in members pulling between clubs. One or two clubs within the industry appear with aggressive and immoral means of gaining members. Elite sportsmen try to convert other clubs to increase their club's performance. This is also connected to the competition to gain sponsors. The bigger sports or clubs have better possibilities to gain sponsors. There are also huge differences between performance and youth sport. Clubs connected to local politics or with acquaintances in local business have easier access to sponsorship money. The third point of view is the facility capacities gainer for the club activities. This problem appears especially in big cities with a lack of sport facilities and a wide offer of sports.

Managers perceive coaches as being an integral part of the staff. As was mentioned earlier, communication between members and the organization is through the coaches. Current staff is willing and devoted to the sport organization but managers perceive a lack of qualified and motivated staff. The problem is that coaches are either unpaid or underpaid. Their motivation is based on personal relationships with members and their performance improving. Communication between them is on an everyday basis – very friendly, informal and personal.

Local governments are also perceived as being very important from two points of view. They are frequently the owners of facilities while being the providers of subsidies. As the owner of facilities, the local government is the influencer of rentals – the prices and distribution of a rental schedule between local clubs. The clubs are also competitors not only in facility occupation but also in gaining subsidies from the local government. There is strongly perceived connection of local politics to some sport or club respectively which is reflected in higher support of the club. The transparency of subsidies distribution is perceived as a problem. Similarly, promoting clubs in local government newspapers – the supported clubs usually have more space.

Governing bodies are the guarantor for clubs. The communication and support from the side of GBs are perceived as very weak. The fequently-mentoned problem of GBs is a political fight within the GB board and the result is that the GB serves only as an information channel about sources of subsidies. The only support comes from local

GB offices but it depends on office workers, as they are the source of information about how to prepare request forms for subsidies after the change of subsidies from NGBs to Ministry of Education, Youth and Sports.

The rest of stakeholders were mentioned sporadically and in special relationship to some problem. The communication with media as a stakeholder is perceived negatively, with the majority of space in media being occupied by performance sport, especially the most popular sport. Clubs in the research sample use only the local newspaper and it seems to be a proper way for addressing potential members. Nevertheless, successful clubs also have an advantage in the Word of Mouth Marketing within the community around the club. This helps in special occasions like preparing some competition, repairing the sport facility etc.

Discussion

The results presented of the research were organised in the Mitchell et al. model of stakeholder prioritization (see Figure 1). The model presented is based on generalized results and it is not the same for clubs in the research sample. Each club has some differences in stakeholder positioning according to their behaviour. Nevertheless, parents, trainers, members and competitors are the primary stakeholders with local governments, governing bodies, sponsors and others (community) being secondary stakeholders. Some of stakeholders move between the circles due to the dynamics of the model and differences in the managerial perception.

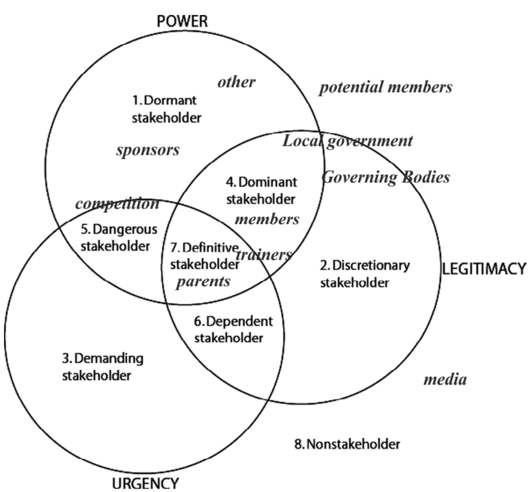

Figure 1

Parents are definitive stakeholders (as they have all three attributes) and their legitimacy is based on their legal responsibility for their child, while also being payers of membership fees and frequently communicate with coaches. Dissatisfied parents take the decision whether their child will visit the club or not. Parents can also build coalitions and use Word of Mouth Marketing. Unsatisfied parents can have dangerous consequences over the long term, as do coaches whose legitimacy is based on their membership and trainers licence. Communication and satisfying needs are carried out in a very short time period. On the other hand, members do not put undue pressure on the process − they only want to play a sport. Competition crosses the border between Dormant and Dangerous stakeholder and it is closely connected to the speed of competition activities. Crossing borders is also in case of local government and governing bodies which have the legitimacy, but use the power very sporadically. Sponsors are a special kind of stakeholder that has the power of sponsorship money. Communicating with sponsors should be done very carefully, as switching costs to another club are very low. The rest of stakeholders do not require much attention; nevertheless, their position could change in the future.

Conclusion

The Mitchell et al. (1997) model seems to be a good tool for analysing primary stakeholders and their distribution. Nevertheless, managers of non-profit sport clubs do not work with stakeholders systematically. They know the main stakeholder groups but hardly define their requirements or goals. Identifying major stakeholder groups would help formulate proper strategy and implement it. The research also showed some differences between its results and the literature review, where the order of the importance of stakeholders was different. This could be useful for managers and academicians in the Czech Republic.

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HEALTHY LIFESTYLE, ACTIVE AGING

BODY HEIGHT, BODY COMPOSITION AND LIFESTYLE OF CZECH HIGH SCHOOL STUDENTS

Hrazdíra Eduard, Grasgruber Pavel, Hlavoňová Zuzana, Svobodová Marie, Králová Tereza, Cacek Jan, Kalina Tomáš, Stračárová Nikola, Huleš Jan, Bokůvka Dominik
Faculty of Sports Studies, Masaryk University Brno, Czech Republic

Abstract

The purpose of this anthropometric research, which took place in Moravian high schools between 2016-2017, was to examine the relationship between body height, body composition (measured via bioelectric impedance on the device InBody 720) and some aspects of lifestyle (surveyed via a questionnaire). The target group was high school students aged 17-20 years, from a full range of secondary schools. The research specifically focused on factors that correlated most strongly with body height and obesity prevalence, which may potentially have very important implications for the preparation of nutritional recommendations in the school catering system.

Key words: *High school students, physical growth, obesity, body composition, InBody720*

Introduction

According to the most recent nationwide survey from 2001, the young population of the Czech Republic reached a mean height of 180.3 cm in boys and 167.2 cm in girls at the age of 17 years (Vignerová et al., 2006). These values are remarkable because they are the highest in Central Europe and among the highest in the world, despite the fact that the average level of nutrition in the Czech Republic is not extraordinary in the European context (Grasgruber et al., 2014; 2016). Genetic predispositions also do not appear to be exceptional, at least from the perspective of Y haplogroup frequencies that correlate quite strongly with height in 45 countries (Grasgruber et al., 2014).

Since 2001, there has been a major gap in the anthropological research of the Czech youth because the Ministry of Education did not support the planned 7th nationwide survey in 2011. The research of the secular height trend has thus remained limited to certain regions. Samples from two recent studies performed in Central and Northern Moravia (Kutáč, 2013; Kopecký et al., 2014) are rather small, but the results (a mean height of 180.3-181.0 cm in boys and 167.6-167.9 cm in girls aged 18 years) are in line with the data from the 6th nationwide survey and indicate that the positive height trend may further continue.

In our own survey "Physical fitness in the Czech Republic" performed between 2011-2014, we measured height and body composition in a random sample of 1668 volunteers aged 18+ years (Figures 2A-2B). This subpopulation was apparently taller than 17-year old boys in previous nationwide surveys, probably due to the self-selection of healthy conscious individuals, but the most fundamental observation was the trend *within* this group: Whereas it showed signs of levelling-off in girls, it continued in boys. The youngest birth cohorts included into this survey were those from the early 1990s.

Because our model based on ecological data (Grasgruber et al., 2016) predicted only 179.0 cm for young Czech men, and young Czechs are even taller than their Slovak peers, who were only 179.3 cm tall in 2011, at the age of 18 years (L. Ševčíková - pers. communication), it would be interesting to examine exogenous variables influencing the extraordinary stature of Czechs. Our preliminary hypothesis was that the height of the Czech population is positively influenced by the system of school catering, which may be one of the most sophisticated in the world. Until recently, the recommended daily doses of protein for the growing youth were much higher than in the official WHO recommendations and even in neighbouring countries in Central Europe, including Slovakia.

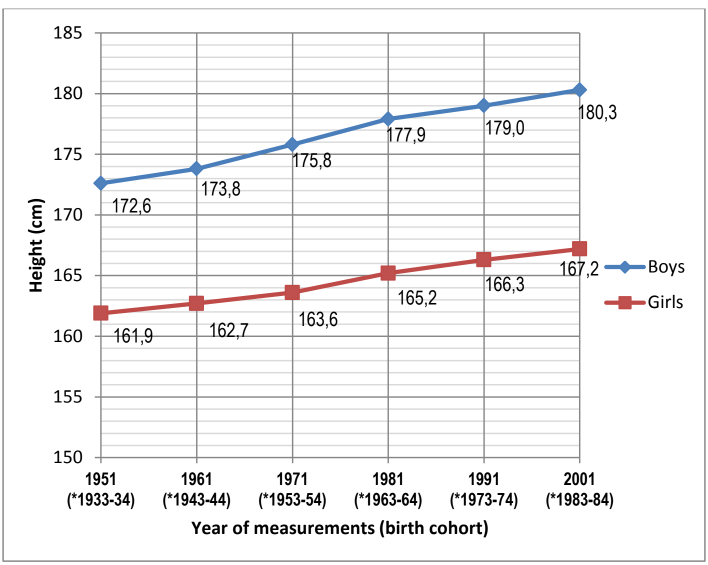

Figure 1. *Average height of 17-year old boys and girls in nationwide anthropometric surveys between 1951-2001 ('smoothed' values). Source: Vignerová et al. (2006).*

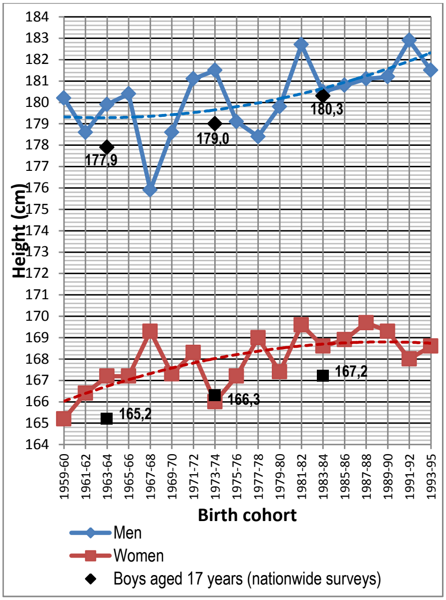

Figure 2A. Average height of men and women in the research "Physical activity in the Czech Republic (2011-2014)". Means of two-year birth cohorts.

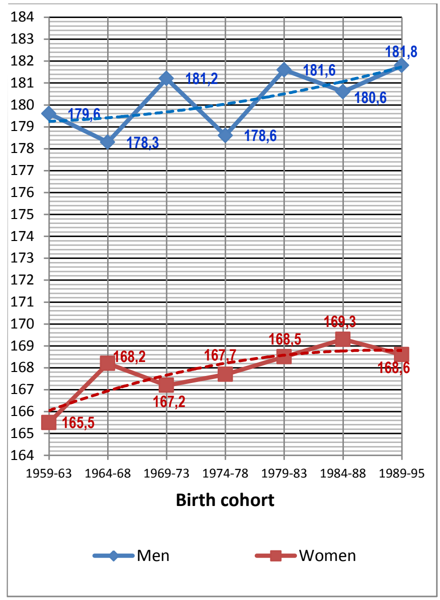

***Figure 2B.** Average height of men and women in the research "Physical activity in the Czech Republic (2011-2014)" Means of five-year birth cohorts.*

The second problem that we wanted to address in our study is the growing prevalence of obesity in the Czech youth. Although the trend may have already stopped, the prevalence of obese children aged 5-17 years has increased from 5.3% in 1996 to 10.3% in 2016 (Kratěnová et al., 2017). Therefore, it would be important to identify characteristics of lifestyle that contribute to this increased prevalence.

Methods

The survey of the Czech youth has been underway since June 2015. In its first stage, we measured stature in boys and girls aged 17-20 years at high schools in the city of Brno and its surroundings. The results have not been published yet. The second stage started in September 2016 and included a much more detailed examination of the students' body composition and lifestyle. Preliminary results of this second stage will be presented in this article. Because data on boys are still limited, we will discuss only results in girls.

Similar to the first stage, the target group were high schoolers aged 17-20 years. The survey was conducted at high schools in the regions of South Moravia and Vysočina. All types of high schools were targeted, and they were divided into three groups: A) elite high schools *(gymnázia)*, B) schools with the predominance of leaving exams *(maturita)*, and C) mostly vocational schools with the equal representation or predominance of apprenticeships without leaving exams.

At first, students received a questionnaire aimed at the examination of their everyday lifestyle. Among other things, it included questions on the education of their parents, the attendance of school lunches and the frequency of dairy consumption. Judging from the results of our ecological studies (Grasgruber et al., 2014; 2016), dairy is the major dietary factor affecting physical growth worldwide. As for the frequency, the students had three options ("never", occasionally", "daily"). Subsequently, we measured their stature, using a mobile stadiometer SECA 213. Finally, the students underwent measurements of body composition via the device InBody 720 (bioelectrical impedance).

Results

The sample included 740 girls aged 18.4±0.7 years on average (age range 17.0-20.8 years). Table 1 compares individual categories of schools. The height of girls from elite schools (category A) was significantly higher (~2 cm) than the height of girls from the category B ($p<0.001$) and C ($p=0.002$). Similarly, the BMI of girls from elite schools was significantly lower than in the category B ($p=0.008$) and C ($p<0.001$). Even more pronounced differences existed in the percentage of body fat ($p<0.001$ with both groups). The proportion of obese girls at elite high schools was almost twice lower than at high schools from categories B and C. This can also be ascribed to their higher levels of physical activity. Girls from category C seem to have more developed muscle mass but this is undoubtedly due to the weight of fat that they carry.

Table 1. Comparison of girls at different types of schools.

	n	Height (cm)	Weight (cm)	BMI (kg/m^2)	BMI >25 kg/m^2 (%)	% body fat	% body fat >35%	% physically inactive	% underdeveloped muscle mass
A (Gymnázium)	240	167.7±5.8	61.5±10.3	21.83±3.35	15.4	26.2±7.0	12.9	36.7	30.0
BC (Leaving exams >)	273	165.7±6.0	62.6±13.0	22.76±4.30	24.5	28.8±8.0	23.4	39.9	30.4
D (Apprenticeship >)	227	166.0±6.3	64.1±13.0	23.24±4.39	27.3	29.3±7.7	21.6	49.8	22.5
Total	**740**	**166.5±6.1**	**62.7±12.2**	**22.61±4.09**	**22.4**	**28.1±7.7**	**19.5**	**41.9**	**27.8**

Information from questionnaires was not available for all girls because some of them missed certain questions. The comparison of girls divided according to the attendance of school lunches (Table 2) shows very marked differences between girls attending school lunches daily (Group 3), and girls attending school lunches occasionally or never (Groups 1 and 2). Girls attending school lunches daily are ~2 cm taller ($p<0.001$ with Groups 1 and 2). They also have less body fat on average, although only the difference between groups 3 and 1 reached statistical significance ($p<0.001$). The proportion of obese girls in Group 3 is also much lower (-4.1% when compared with Group 2 and -8.5% when compared with Group 1).

Interestingly, the differences between Group 3 and Groups 1-2 further increase, when we take additional factors into account. The role of social status (university education of parents) is not particularly large on its own but it combines favourably with nutrition. Girls from Group 3, who consume dairy daily and have at least one parent with university education, reach an average height of 169.3 cm, with 8.9% incidence of obesity. That's a difference of almost 4 cm and -14.7%, when compared with Groups 1-2.

Table 2. Comparison of girls according to the attendance of school lunches at high school.

Group	Category (according to the attendance of school lunches + other characteristics	n	Height (cm)	Weight (cm)	BMI (kg/m^2)	BMI >25 kg/m^2 (%)	% body fat	% body fat >35%	% physically inactive	% underdeveloped muscle mass
1	**School lunches never**	**309**	**165.8±6.1**	**63.8±13.7**	**23.19±4.64**	**25.9**	**29.4±8.1**	**23.6**	**41.1**	**26.9**
1a	&Parents w/o univ. education	247	165.7±5.9	63.9±14.3	23.24±4.88	25.9	29.7±8.3	23.9	44.1	26.7
1b	&Univ. educated parent(s)	62	166.4±6.8	63.7±10.8	22.98±3.52	25.8	28.6±7.2	22.6	30.6	27.4
2	**School lunches occasionally**	**156**	**165.4±5.9**	**60.7±10.8**	**22.17±3.62**	**19.9**	**27.9±7.5**	**19.2**	**40.4**	**34.0**
2a	&Parents w/o univ. education	101	165.7±5.8	61.8±10.9	22.50±3.67	23.8	28.5±7.6	22.8	40.6	33.7
2b	&Univ. educated parent(s)	55	164.9±6.1	58.5±10.3	21.48±3.42	12.7	26.4±7.1	12.7	40.0	34.5
3	**School lunches daily**	**271**	**167.8±6.1**	**62.7±10.9**	**22.26±3.53**	**19.9**	**26.8±7.2**	**15.1**	**43.2**	**24.7**
3a	&Parents w/o univ. education	165	167.6±6.0	63.4±11.2	22.54±3.65	23.0	27.2±7.3	16.4	44.8	20.6
3b	&Univ. educated parent(s)	106	168.0±6.2	61.5±10.3	21.78±3.28	15.1	26.2±7.0	13.2	39.6	33.0
3c	&Dairy daily	136	168.4±6.4	63.0±10.7	22.19±3.49	18.4	26.8±6.9	13.2	39.0	25.7
3d	&Dairy daily &Univ. educated parent(s)	56	169.3±6.3	61.5±8.9	21.47±2.94	12.5	25.4±6.2	8.9	35.7	35.7

The role of dairy (on its own) also isn't large, explaining only a 0.7 cm difference in height between girls consuming dairy daily and those, who consume dairy occasionally or never (Table 3). The difference in height (p=0.15), BMI (p=0.55) and % body fat (p=0.15) is not significant. However, we must take into account that the key factor is total dairy consumption, which may not be fully identical with frequency.

Table 3. Comparison of girls according to the consumption of dairy.

	n	Height (cm)	Weight (cm)	BMI (kg/m^2)	BMI >25 kg/m^2 (%)	% body fat	% body fat >35%	% physically inactive	% underdeveloped muscle mass
Dairy daily	345	166.8±6.5	62.7±12.7	22.52±4.18	20.3	27.7±7.7	19.4	39.7	27.8
Dairy occasionally/never	394	166.1±5.8	62.7±11.8	22.71±3.99	24.4	28.5±7.7	19.5	43.4	27.7

Table 4 displays differences between girls according to the education of their parents. The difference in height is 1.2 cm, but it is not significant (p=0.11). However, the difference in BMI (p=0.045) and % body fat (p=0.01) reaches significance. This finding suggests that living in a well-educated family has a marked influence on the incidence of obesity, which is also demonstrated by the graphs above.

Table 4. Comparison of girls according to the education of their parents.

	n	**Height (cm)**	**Weight (cm)**	**BMI (kg/m^2)**	**BMI >25 kg/m^2 (%)**	**% body fat**	**% body fat >35%**	**% physically inactive**	**% underdeveloped muscle mass**
No parent	516	166.3±6.0	63.3±12.8	22.87±4.31	24.6	28.6±7.9	21.1	43.6	26.4
Both parents	73	167.5±6.8	61.2±9.3	21.82±3.07	16.4	26.1±6.9	13.7	38.4	24.7

Because the survey is still underway, the results must be taken only as preliminary. Still, we have already observed very interesting findings with potentially far reaching implications. To our knowledge, the only similar research conducted in the Czech Republic is the ELSPAC project (www.elspac.cz). Some detailed results of this survey have already been published (Bienertová-Vašků et al., 2017). The authors compared the height of 835 children at various ages with the dietary pattern of their mothers, based on self-reported food consumption, but they haven't found any significant relationship. We purposely avoided self-reported food questionnaire, due to its notorious unreliability, and concentrated on the consumption of dairy which is the major factor influencing height in ecological studies. The students had only three options for most questions in the questionnaire ("never", occasionally", "daily") which enabled to distinguish groups with radically different lifestyles. Obesity was determined by both the BMI and via measurements with Inbody720, and the observed prevalence can be mutually compared.

First of all, we observe that girls attending school lunches regularly don't differ from other girls in terms of physical activity, but their obesity rates are much lower. Girls attending school lunches occasionally or never also lag behind in terms of stature. At the same time, our data indicate that these differences cannot be fully explained by differences in social status. Girls from well-educated families may be less obese and somewhat taller, but the differences in height and obesity rates are larger, when we compare girls according to the attendance of school lunches. Therefore, these data support our initial hypothesis that the system of school catering is a factor that could explain the extraordinary height of the Czech population, and it can also play a significant role in the prevention of obesity. Nevertheless, more convincing conclusions will be possible, when we collect more representative data for both sexes.

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THE LEVEL OF PHYSICAL ABILITIES OF HEALTHY SENIORS AND PATIENTS WITH MILD COGNITIVE IMPAIRMENT

Sklenaříková Jana, Skotáková Alena, Vaculíková Pavlína, Grmela Roman, Svobodová Lenka, Sebera Martin
Masaryk University, Faculty of Sport Studies, Brno, Czech Republic

Purpose: Alzheimer´s disease (AD) is the major cause of dementia in seniors. Pharmacological disease as a modifying treatment is not available and increasing attention is thus being given to non-pharmacological approaches. The aim of this article was to compare the results of Senior Fitness Tests of two groups – healthy seniors (HS) and patients with mild cognitive impairment (MCI) in AD. Methods: 69 subjects were included in the study, randomized group attended a 6 months dance-exercise intervention with 50 training units. Initial and output examination included "chair stand test", "8 foot test", "6 minutes' walk test". Results: The difference between MCI group and HS group was not significant. Groups achieved similar results in three seniors test. Findings confirmed the similarity of the two groups.

Key words: *Alzheimer's disease, healthy senior, Senior Fitness Test, dance*

Introduction

Dementia, most commonly caused by Alzheimer's disease (AD), is one of the most alarming age-related diseases, leading to the loss of socioeconomic status and personal identity. Considering that currently 79,000 people are diagnosed with AD in the Czech Republic and that the incidence of the disease increases with age (5% of the population has AD at the age of 60; 50% at the age of 85), the number of patients will increase rapidly in the future (Rektorova 2012a). Despite very intense pharmacological research, a new drug is not expected before 2030. Therefore, increasing attention is being given to possible preventative and affordable non-pharmacological approaches, such as physical activity.

The intention of the future study is to find out if specifically, structured and optimized dance-exercise intervention delivered at an individualized load for a six-month period will positively influence brain structure and fitness function both in healthy older individuals and in subjects with existing objective cognitive decline at a stage of mild cognitive impairment (MCI).

The aim of our study was to compare the input information of two test groups using Senior Fitness Tests - healthy seniors (HS) and Patients with MCI in AD.

Methods

Study sample

Study was piloted in a sample of 69 older adults over the age of 60. 47 was HS and 22 patients with MCI in Alzheimer's disease. All participants were non-smokers, without serious brain injury, without major depressive disorder, without history of central nervous system disease, without serious neurological, psychiatric, orthopedic, cardiovascular, or other internal or oncological diseases that would impede the implementation of dance and movement activities in the specified scope and duration. The abuse of alcohol or other addictive substances excluded participants from the study. All participants had not to be currently engaged in a regular sport activity that is more frequently practiced and/or more demanding than our intensive dance-exercise intervention based on a structured interview. All participants were asked to sign an informed consent form approved by Ethics Committee of Masaryk University, Brno.

Specific criteria for different groups

MCI participants were diagnosed according to the criteria and based on the clinical judgement of our neurologists specialized in cognitive impairment and dementia and on a detailed neuropsychological evaluation done by a skilled neuropsychologist (Rektorová, 2012a). MCI patients were recruited from consecutive patients already followed at the Centre for Cognitive Impairment at the First Department of Neurology, St. Anne's Teaching Hospital, School of Medicine, Masaryk University, Brno.

Healthy seniors revealed normal cognition based on a detailed assessment performed by a neuropsychologist. Healthy senior participants were recruited using the snowball technique from several sources. A cooperating organization which provided education for seniors were addressed, recruitment was also be carried out free advertising in community newsletters and in key places (libraries, local authorities, etc.).

Both groups will undergo a 6-month dance-exercise intervention (a total of 72 training units, each lasting for 60 min, 3 times a week, with innovative dance choreography). All subjects were assessed at baseline before 6 months program utilizing the level of physical fitness using standardized tests lasting about 25 minutes.

Test no.1: "Six minutes' walk test" assess aerobic endurance.

Test no.2: "Chair stand test" assess lower-body strength.

Test no.3: "8-foot Up and Go test" assess agility and dynamic balance (Rikli and Jones, 2013) and BMI characteristics.

Results

In total, 69 participants were divided into two groups: MCI (n = 22) and HS (n = 47). Table 1 show that the data from both groups are similar in terms of sample size, age, high, weigh and BMI.

Table 1. Group characterization of the participants.

Category	Count	Cumulative Count	Percent	Age	High	Weigh	BMI
MCI	47	47	68,11594	67±11	169.8±14	89.31±47	30.65±12
HS	22	69	31,88406	72±4	167.1±13	73.3±24	26.06±26
Missing	0	69	0	0	0	0	0

Notes: MCI – mild cognitive impairment; HS – healthy senior

Table 2. Result of senior fitness test

Variable	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std. Dev.
6 min walk	47	582,0213	600,0000	380,0000	710,0000	525,0000	645,0000	82,76092
chair stand	47	15,6809	15,0000	9,0000	24,0000	14,0000	18,0000	2,94962
8 foot	47	5,1617	4,9000	3,5000	10,7000	4,4000	5,5000	1,22839

Table 3.: Basic descriptive statistics of group MCI

Variable	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std. Dev.
6 min walk	22	549,3182	575,0000	400,0000	655,0000	480,0000	610,0000	75,97455
chair stand	21	16,2381	15,0000	11,0000	27,0000	13,0000	17,0000	4,47107
8 foot	22	5,1000	5,0000	3,5000	7,1000	4,5000	5,6000	0,95768

The difference between MCI group and HS group in fitness Test no.3 ("8-foot test") and Test no.2 ("Chair stand test") (see Table 2 and 3; Fig. 1, Fig.2 and Fig.3) was not significant. Both groups achieved similar results in two senior fitness tests.

In contrast, groups are different concerning general results of aerobic endurance (See Table 2 and 3 and Fig.1).

Based on normality tests, we reject the hypothesis of normal data distribution, so we will use nonparametric tests: Test of normality (Table 4) and Mann-Whitney U Test (Table 5).

Table 4.: Tests of Normality

Variable	N	max D	K-S p	Lilliefors p	W	p
6 min walk	69	0,139999	p < ,15	p < ,01	0,955916	0,016033
chair stand	68	0,144839	p < ,15	p < ,01	0,935848	0,001691
8 foot	69	0,145112	p < ,15	p < ,01	0,861400	0,000002

Table 5: Mann-Whitney U Test

variable	Mann-Whitney U Test (w/ continuity correction) by variable MCI Marked tests are significant at p <,05000						
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value
6 min walk	1780,500	634,5000	381,5000	1,738261	0,082166	1,739024	0,082031
chair stand	1629,000	717,0000	486,0000	0,092919	0,925968	0,093551	0,925466
8 foot	1634,500	780,5000	506,5000	-0,128760	0,897548	-0,128946	0,897400

There are no statistically significant differences between HS and MCI in any motor test. Respective differences are seen here, but not so large as to be statistically significant.

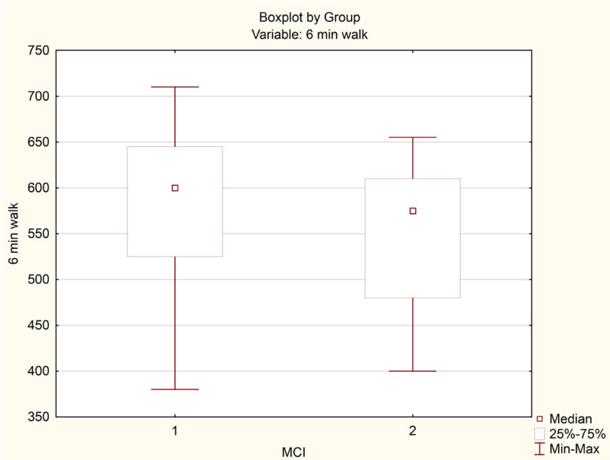

Figure 1. Variables: "6 min. walk test". HS = 1. MCI = 2

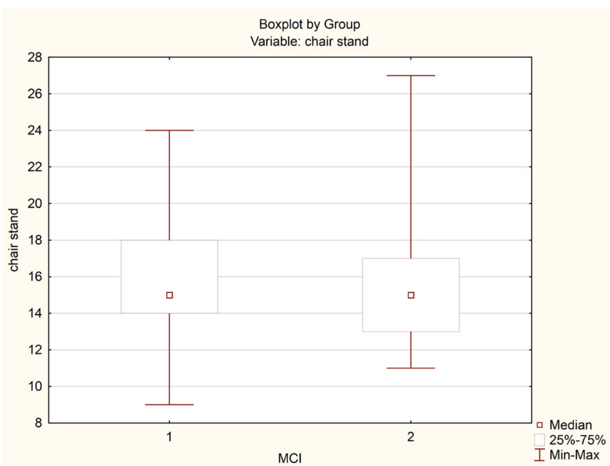

Figure 2. Variables: "Chair stand test". HS = 1. MCI = 2

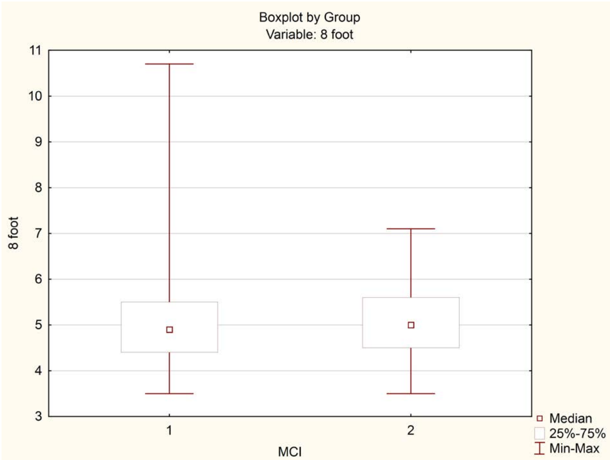

Figure 3. Variables: "8 food test". HS = 1. MCI = 2

Discussion

Regarding the use of specific physical intervention, it has been shown that learning a new skill (juggling for three months) induced changes in cognitive areas involved in the visual spatial and memory functions (Draganski 2004, Scholz 2009).

Dancing is, in comparison to other aerobic activities (i.e. walking, biking), a relatively complicated balancing and rhythmic act that combines the effects of learning of new skill (choreographed dancing) and practicing intense aerobic exercise. Most studies show a positive effect of dance exercise intervention on the postural and functional mobility of seniors. The positive effect of dance as long-term physical therapy on cognitive function in older people was reported by Berrol (1990); other authors noted the improved of attention and psychomotor speed (Coubard 2011; Keogh 2009; Kimura and Hozumi 2012).

Results of our pilot study confirmed the similarity of physical fitness of two groups before the planned intervention program.

The interventional exercise program will be carried out at a moderate intensity of physical activity and will always well matched to the current state of health and level of functional fitness and cognitive abilities. Each exercise unit (60 minutes) will contain elements of dance therapy, preparatory and general exercises will be focused on developing good posture, breathing and relaxation exercises. An experienced trainer and an assistant will be conducted the individual lesson.

After each dance-movement lesson, feedback from the participating seniors will be obtained using a standard evaluation sheet for each lesson.

Conclusion

Although MCI group was compared to the group HS younger, with larger average weight and BMI index the results of Test no.1 and no.2 were with the minimum difference. A more significant difference can be observed in aerobic endurance when a group of HS has reached values above average in comparison with the general population.

With this study, we observed that selected groups have a quality starting position for future research project. The project results will enhance our knowledge and understanding of the dance-exercise intervention and its impact on HS and MCI subjects.

Acknowledgments

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ASSOCIATION BETWEEN THE FEAR OF FALLING AND THE LEVEL OF PHYSICAL ACTIVITY IN OLDER ADULTS

Svobodová Lenka, Sebera Martin, Sucháčková Petra
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

Purpose: We live in the era of aging population. According to statistical forecasts by 2030 the proportion of people aged 65 and older will increase up to 25%, it means almost up to twice as much as in these days.

It is necessary to focus not only on the length of life but also on its quality. Many studies are already dealing with determinants related to the quality of life. One of the limiting factors is inherently the level of physical activity. This study investigated the association between habitual physical activity and perception of fear of falling (FOF) in older adults.

Methods: To measure the level of fear of fall, we used a standardized questionnaire. The Falls Efficacy Scale-International (FES-I) is a short, easy to administer tool that measures the level of concern about falling during social and physical activities inside and outside home whether or not the person actually does the activity. The level of physical activity was evaluated by answering questions about the type, length and intensity of physical activity. The number of 206 older adults were grouped according to METs (METs are calculated from their physical activities), gender and age. For differences between groups we used statistical methods: nonparametric t-test and nonparametric analysis of variance (ANOVA). Statistical significance is calculated on alfa-0.05, for effect size we used Cohen´s d and η^2.

Results: We have found differences among age groups in perception of fear of falling ($p=0.000$, $d=0.67$). There are not differences between gender ($p=0.727$, $d=0.13$). We revealed differences among level of METs ($p=0.000$, $\eta^2=0.093$).

Conclusion: Our study contributes to the statement which says that the level of physical activity can have an influence on quality of life in older adults in association with fear of falling.

Key words: f*ear of falling, perception, older adults, physical activity, MET*

Introduction

As we know ageing is a dynamic and progressive process that results in deterioration of morphological, functional, hemodynamic, and psychological abilities and leads to a reduced adaptive ability and quality of life, as well as increased morbidity (Roubenoff, 2000). As a result of the ageing process, the number of falls also increases.

Falls in older adults can often lead to physical injuries and psychological trauma. In fact, falls in the population aged 65 and over lead to high rates of mortality and morbidity. Consequences of falls in the elderly are also very expensive for the society. With the rising number of elderly in the society there is an increasing need for paying attention to the issue of falling.

Generally, the falling of the elderly is caused by four main categories of risk factors. Figure 1 presents a model illustrating how these different types of risk factors both individually and interactively contribute to the heightened risk for falls and fall-related injuries.

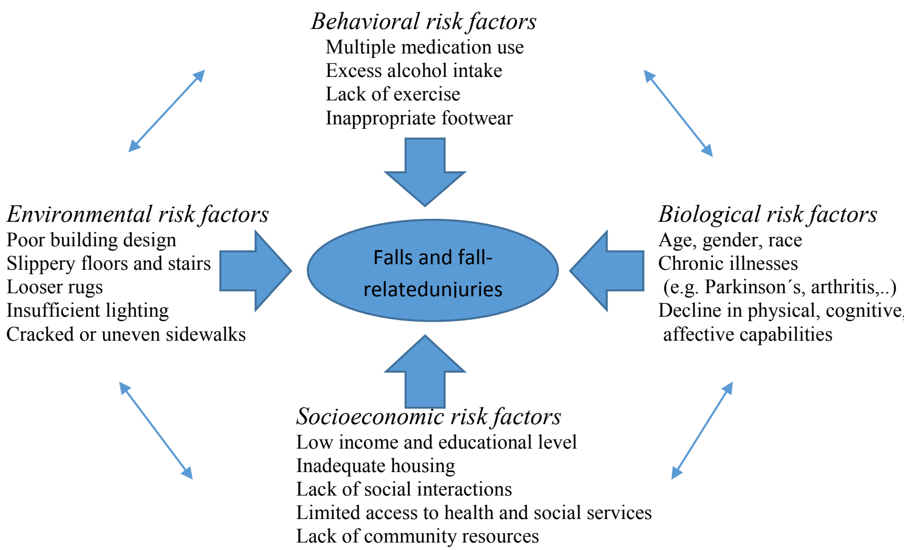

Figure 1. Risk factor model for falls in older age (World Health Organization, 2008)

Although fear of falling is not a medical condition per se, this psychological syndrome has been identified as a risk factor for falls (Debra, 2010). In fact, this fear can be assessed with a single question: “Are you afraid of falling?” The obvious problem with this type of research is that it is impossible to determine the directionality of any observed associations: did fear of falling cause the poor health, or vice versa? (Cumming, Salkeld, Thomas & Szonyi; 2000). Tinneti, Richman & Powell (1990) has improved assessing fear of falling. He and his coworkers have extended the concept of fear of falling by assessing fall-related self-efficacy. The FES assesses an older person's confidence in performing a series of everyday tasks without falling. The new assessing tool (Falls Efficacy Scale-International - FES-I) includes among its sixteen items the social factors, as the social factors play a significant role in the life of the elderly.

We know that physical activity (PA) is closely related to healthy lifestyle. PA also plays a crucial role during aging. In this period, however, there are more variables that PA is influenced by. One of them is namely the fear of falls.

We supposed that older adults who are afraid of falling are likely to reduce physical activity to prevent falls. To reduce falls outdoors, older people should first build up their physical abilities in a safe environment before being encouraged to increase outdoor physical activity (Wijlhuizen, Jong & Hopman-Rock, 2006). Researchers focused on assessment of physical activity in older adults use accelerometer or questionnaire. We wanted to extend this type of studies, thus we investigated the association between habitual physical activity and perception of fear of falling in older adults.

Methods

Due to the fact that researchers dealing with seniors are not consistent uniform in setting the lower age limit of seniors, we have set our lower limit to 60 years. The participants were 206 elderly people (50 men, 156 women; mean age 71.9±6.3 years; mean age men 72.4±5.9 years; mean age women 71.8±6.4 years). We used nonprobability sampling design.

To measure the level of fear of fall, we used a standardized questionnaire. The Falls Efficacy Scale-International (FES-I) is a short, easy to administer tool that measures the level of concern about falling during social and physical activities inside and outside home whether or not the person actually does the activity. The level of physical activity was evaluated by answering questions about the type, length and intensity of physical activity. METs (METs are calculated from their physical activities), gender and age. This unit combines the information on the duration of a given activity and its intensity and also enables the researchers to compare diverse types of activities. The number of MET minutes for a given activity is calculated by using a simple formula: MET min = duration in minutes x MET score of the given activity, while 1 MET = 3,5 ml (O_2) $\cdot$ $kg^{-1} \cdot min^{-1}$, 1 MET ≈ 1 kcal $\cdot$ $kg^{-1} \cdot h^{-1}$

For differences between groups we used statistical methods: nonparametric t-test and nonparametric analysis of variance (ANOVA). Statistical significance is calculated on alfa-0.05, for effect size we used Cohen´s d and η^2.

Data analysis

The participants were divided into two groups based on age: 60-74 and 75-89 years. After rejecting hypothesis about normality, the differences between those groups were compared using the Mann–Whitney U test. In the following stage the participants were divided into three groups based on METs: 0, 1-5 and > 5 MET. The differences between those groups were compared using the Kruskal-Wallis test. The significance level was set at 5% Effect sizes Cohen d and eta^2 (η^2) were calculated. Statistical analyses of the data were performed using Statistica 64 (version 13.0; Dell Inc,).

Results

Table 1. Results of Mann-Whitney U Test, groups based on age

Variable	Mann-Whitney U Test By variableage						
	Rank Sum 60-74	Rank Sum 75-89	U	Z	p-value	Valid N 60-74	Valid N 75-89
FES-I	12757,00	8564,000	3166,000	-3,79161	0,000150	138	68

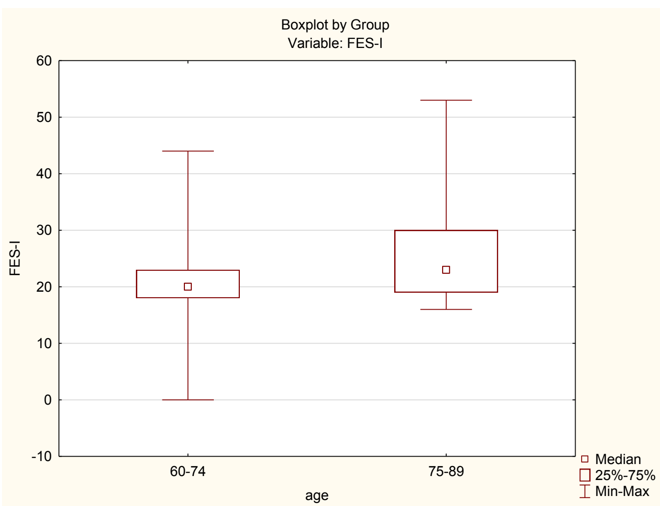

Figure 2. Differences between age groupsin perception of fear of falling

As table 1 and figure 2 showwe have found differences between age groups in perception of fear of falling (p=0.000, d=0.67). This difference is statistical and practically significant. Older people have higher perception of fear of falling.

Table 2. Results of Kruskal-Wallis test, groups based on METs

Depend.: FES-I	Kruskal-Wallis ANOVA by Ranks; FES-I Independent (grouping) variable: METs Kruskal-Wallis test: H (2, N= 206) =19,09481 p =,0001			
	Code	Valid N	Sum of Ranks	Mean Rank
0 METs	101	104	12284,50	118,1202
1-5 METs	106	47	4919,50	104,6702
>5 METs	107	55	4117,00	74,8545

Depend.: FES-I	MultipleComparisons p values (2-tailed); FES-I		
	0 METs R:118,12	1-5 METs R:104,67	>5 METs R:74,855
0 METs		0,597719	0,000040
1-5 METs	0,597719		0,035412
>5 METs	0,000040	0,035412	

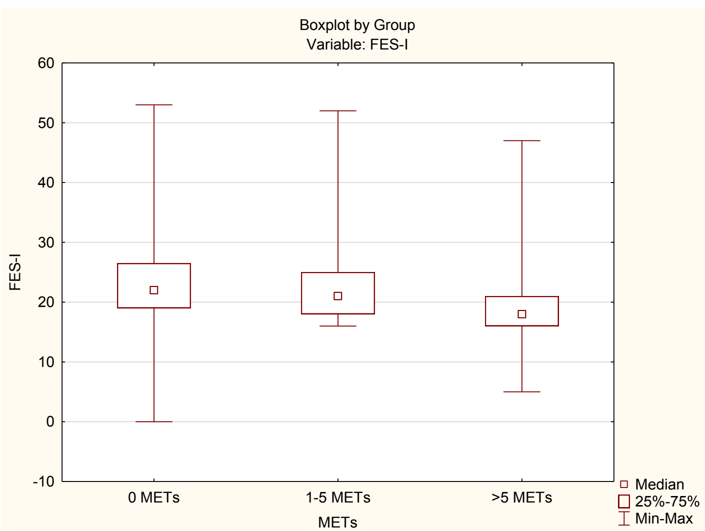

Figure 3. Differences among METs groups in perception of fear of falling

As table 2 and figure 3 show we have found differences among METs groups in perception of fear of falling ($p=0{,}000$, $\eta^2=0{,}093$). This difference is statistical and practically significant. People with higher METs have lower perception of fear of falling.

Discussion

Fear of falling has been considered a health problem among older people for years. In previous studies the correlation between falls and fear of falling has been demonstrated, but the temporal relationship between these two syndromes in a population based sample is not sufficiently elucidated (Friedman, Munoz, West, Rubin & Fried, 2002). Thus the findings of some studies also suggest that risk factors for indoor and outdoor falls are different. Location of fall may be an important confounder in studies of predictors of falls in the elderly which should encompass this type of information (Bergland, Jarnlo & Laake, 2013).

We know that falls and fear of falling can be caused by many factors. It is quite possible that each is a risk factor for the other, an individual who has one of these factors is at risk for developing the other. This in turn may set off a "vicious cycle" of fear of falling, falls and many other adverse consequences.

Studies dealing with the relationship between FOF and PA confirmed specific relationship, however FOF was not independently associated with physical activity when accounting for physical function (Hornyak, Brach, Wert, Hile, Studenski & Vanswearingen, 2013). Regarding to behavioural risk factors, incorporating of broader variety of self-protective exercises is highly recommended (Vít & Reguli, 2017).

Our study confirmed the relationship between perception of fear of falling and the level of physical activity. Our findings link to the statement that PA is related to the perception FOF.

But it is important to say it depends on the intensity of physical activity. We can see that PA with a lower intensity than 5 METs does not have any significant influence on the level of fear of falling.

For instance, a person participating in light housework such as cooking, dishes, ironing would be exercising at approximately 2.5 METs or person who does gardening (digging, raking, weeding) - 4 METs or walking for exercise 3 km/h - 1.8 METs, 5 km/h - 3.2 METs, 7 km/h - 5.3 METs.

The weakness of our research was the method of measurement of PA. It will be more precise to use accelerometers.

Conclusion

Based on previous studies older adults who are afraid of falling are likely to reduce physical activity to prevent falls.

In general, we can recommend to reduce falls older people should first build up their physical abilities in a safe environment and continue by increasing the load.

We will examine how we can influence the perception of fear of falling by specific type of PA and association among risk factors. We will continue our study by identifying which type of physical activity is best for this group of people even with regard to the appropriate the intensity of load.

Further studies are needed to determine whether physical activity can be useful in reducing the number of falls and their consequences, perception of fear of falling and its relationship to quality of live.

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FREE-TIME ACTIVITIES OF CHILDREN OF YOUNGER AND OLDER SCHOOL AGE

Teplicancova Maria, Almasiova Angela, Kostial Jan
Faculty of Education, Catholic University, 034 01 Ruzomberok, Slovakia

Abstract

In the contribution we deal with the involvement of children of younger and older school age in selected leisure activities. We focused on sports activities, spending time with friends, spend time with your computer and watching TV. Research data were collected by using the non-standardized author's questionnaire. Of the total number of 1489 questionnaires, 618 were usable. The sample was a random sample of children parents from three selected primary and secondary schools in Ruzomberok. The obtained data was processed using descriptive and inferential statistics in SPSS.

The results show that majority of children need to perform physical movement more than once a week; but there were also found relatively enough children who do not need any physical movement at all. The most frequented leisure activities of children are watching TV along with computer play. However, in these primary and secondary school children is still a strong need for social contact with their peers.

Key words: *Free-time activities, school children*

Introduction

The current society situation in our country is characterized by a dynamic change of the specific functions of the state also in the social sphere. An informal approach to socialization and upbringing in leisure activities is important, which means creating suitable conditions for meaningful leisure time spending with a choice based on needs and interests. The basis for work with children and youth can be found in the Council of Europe material in the Concept of State Policy on Children and Youth in the Slovakia, which represent the importance of informal and interest education (Kratochvilova, 2004). Regarding the use of leisure time, there are found specific goals in this Concept (Stupak, 2009). In current research conducted in Slovakia compared to the outcomes of the 1970s and 1980s, there is a significant shift from active leisure to passive, but regional differences are known as well (Stupak 2009). The impact of many factors in the changed conditions of the society after 1989, but also in the changed attitudes towards values, is notable. According Hambalek (2005), the way of organizing free time - leisure time behaviour leads to various forms of activities such as:

• Unstructured (free) activity that understands the spontaneous activities of people who use available leisure time resources (private resources such as gardens, cottages, books, the mass media, as well as shopping and entertainment centres, free natural areas, playgrounds, sports fields and etc.)

• Structured (more or less organized) activity by which he understands the activities offered by an organization or leisure institution on a commercial or non-profit basis.

One of the forms of meaningful leisure time is movement / physical activity, which is an essential part of external stimulation focused on optimal physical development and mental balance. It is a factor that accompanies man during his phylogenetic and ontogenetic development (Liba, 1999).

The source of primary patterns of children's behaviour is the family that sets the foundations also for leisure time spending. And so, children, besides patterns of behaviour, also take over ways for leisure time use. The influence of parents, siblings, other relatives and family friends is largely synergistic about the behaviour and acting of children. Well-organized family education for leisure time also has a significant preventive character against unwanted effects such as drugs, vandalism, etc. (Kulacsová, 2004). A number of authors point to movement, physical activity and adequate physical fitness level as one of the most accessible and most basic preventive solutions to various risk situations (Sedlacek et al, 2008; Krska, 2008; Bebcakova et al, 2015).

The younger school age (ISCED 1) is characterized by a physical activity that is becoming more intense and purposeful during this period, as brain functions improve, which is also reflected in the interest and desire of children after sporting activities. Spontaneous playing is gradually leaving, and games and activities with rules and mutual competing go through the forefront. Gradually, their activities focus on achieving a particular goal or improving performance. In this period, children enjoy natural activities, especially when they can do running, jumping, crawling etc. (Slip 2006; Krska 2007; Sedlacek et al 2008). The end of this period is characterized by an increasing use of group games corresponding not only to the well mastered children's mobility but also to their social and intellectual development (Krska, 2008; Brodani et al 2015; Vadasova et al 2016).

The age of older school age (ISCED 2) is characterized by gender differentiation, which in practice means that independent exercises in boys and girls are used in the context of physical activity because each gender is interested in and also needs something else. Among boys mostly dominate sports training, endurance and speed activities, and the development of fitness and coordination skills is anticipated and also muscle coordination is greatly improved, while girls are more interested in aesthetic movement, especially in connection with music, and interest in competition is reduced. The opposite case occurs, when children cease to practice movement activities due to loss of primary motivation, by lack of success, lower family support, or negative peers influencing and others (Bobrík, Ondrejková, 2006; Krska, 2008; Krska, 2011; Sedlacek, Pistlova, 2012).

Objectives

The aim of the research was to reveal the extent of involvement of younger and older school children in active or passive leisure activities such as sports, leisure time with friends, computer and television. We wanted also to learn if the choice of children's leisure activities was determined by the economic status of the family and that the parents' own experience with physical activities influenced the choice of leisure activities of their children.

Material and methods

There are more researches with standardized questionnaires, but for our purpose they were not appropriate. The reasons were mostly in other age categories, they were broader or narrower, or other subjects, or did not respond to our topic. So we decided to use the non-standardized authoring questionnaire to implement the research. We processed the data obtained using descriptive and inferential statistics in IBM SPPS Statistics 22. Microsoft Excel 2010.

A survey sample was a randomly selected set of parents of children from three primary schools in Ruzomberok, Slovakia. Out of a total of 1,489 questionnaires distributed personally to selected elementary schools, 692 returned, representing a 46.47%. The survey was attended by 19.9% (123) men and 80.1% (495) women. The average age of respondents is 39.9 years the standard deviation is 6.4, median 40 and modus 40. The youngest respondent is 25 years old and the oldest is 83, which is 58 years of variation range. We attribute this state of affairs to the fact that some of the children are cared for by the elderly parents, that they may also have filled the questionnaire instead of the parents.

Pedagogical interpretation is based on assessment of percentage rates, differences between groups were evaluated with Chi-square test and with Mann-Whitney U-test. Fundamental logical methods like comparison, analyse, deduction and generalization were used in results interpretation.

Results and discussion

1. Scope of engaging children in leisure activities - sports, spending time with friends, spending time with your computer and watching TV

Table 1. Frequency of leisure time spending by selected ways

	daily (%)	several times per week (%)	1 time per week (%)	1-3 times per month (%)	not at all (%)
sport	21.8	48.4	15.3	6.3	8.3
friends	27.2	47.4	15.1	6.5	3.7
computer	25.5	39.0	18.1	7.8	9.7
TV	46.6	41.6	5.8	1.9	4.1

In the case of sports, up to 48.4% of respondents said their child was sporting more than once a week. Daily 21.8% of children are engaged in sports activities, 15.3% of children once a week, of 6.3% only 1 - 3 times per month and 8.3% of parents said their child was not sporting at all.

Daily with friends, according to parents, meet 27.2% of children. 47.4% meet with friends several times per week. 15.1% of respondents report that their child spends free time in friendship companies once weekly, and 6.5% of respondents report that 1 to 3 times a month. They do not even meet 3.7% of children with their friends. 25.5% of children sit at the computer every day. 39% of children spend computer games several times a week, 18% of children once a week and 7.8% of children1 - 3 times a month. 9.7% of respondents report that their child does not spend time at the computer at all.

Regarding watching TV, 46.6% of respondents said that their child spends their free time each day watching TV. More than once a week, 41.6% of children watch TV. Only 1.9% of respondents said that their child is watching TV 1 - 3 times a month, and at least 4.1% of children do not watch TV at all, said parents. As a result, television watching becomes the main leisure activity of children, because of all offered free time leisure options, the majority of respondents said their child was watching TV daily.

2. Differences in the exercise of motion activities by children due to whether or not parents perform physical activities

To determine the differences there was used Chi-square test, which is used to test the combinations of two or more nominal variables (Almasiova, Kohutova, 2016). Table 2 shows that the difference in the exercise of leisure activities of children whose parents perform physical activity and whose parents do not perform physical activity is significant ($p < 0.05$). Children, whose parents regularly perform some physical activity, are more involved in leisure-time motion activities.

Table 1. Movement activity children and parents, Chi-square test

	value	degree of freedom	p-value
Pearson Chi-Square	8.393	1	0.004

76.4% of parents doing some physical activity reported that their child is also doing leisure-time exercise, and 23.6% of these parents said their child did not have any physical activity. Conversely, 65.8% of respondents who do not exercise any leisure time activity reported that their child performs such activity, and 34.2% of these respondents stated that their child did not perform any physical activity.

In relation to the parent's physical activities, we were interested in whether the time of exercise of children's physical activities was influenced by the time of parental activities. To verify this fact, Pearson's correlation coefficient was used, which showed that there was no relationship between the given variables ($p < 0.05$). However, it is interesting that parents spend more time on leisure activities than their children - on average 4.4 hours and children only 2.9 hours per week.

3. The difference in the performance of children's movement activities due to the family's economic status

The Mann-Whitney U-test was used to determine the difference in leisure time activities of children in terms of monthly household income. The test shows that the difference between these two variables is significant ($p < 0.05$). With declining monthly household incomes, the percentage of children exercising leisure-time exercise is also declining. An interesting finding is that the exact half of the respondents (50%), whose monthly household income is less than 300 €, stated that their child either performs or does not exercise leisure-time physical activity. On the contrary, the higher the monthly income of the household, the more often children are involved in free-time physical activities.

Conclusion

Our research shows that sports such as leisure time activities are carried out by almost half of respondents' children more than once a week, almost a quarter of a day. On the other hand, more than a quarter of the respondents 'children spend their free time at the computer and almost half of the respondents' children watch TV daily. When comparing the movements of children and parents, we can state that parents are more concerned with physical activity than their children - parents are 4.4 hours per week on average and children on average 2.9 hours per week. Children whose parents perform some physical activity are more concerned with free-time movements than children whose parents do not move. It has been shown that the length of the exercise activity, but its implementation itself, is not important. The last partial goal was to verify whether the economic status of a family plays a role in the exercise of children's physical activities. It has been shown that there is a difference in the exercise of physical activity relative to the economic status - children of families where higher income is use in their leisure time more often movement activities. We can also point on fact, that prevailing kind of leisure time spending of watched children are passive forms.

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NUTRITION AND REGENERATION IN SPORT

WHY MATHEMATICAL MODELING OF NU-TRITION DOES NOT ALWAYS WORK FOR ATHLETES?

Bielik Viktor
Comenius University, Faculty of Physical Education and Sports, Department of Sports Kinanthropology, Bratislava, Slovakia

Abstract

According literature, nutrition was believed to be a corner-stone for improving performance in the ancient Greece. Since that times we have reports about food composition of ancient athletes which is not meaningfully changing to satisfy current recommendations. Not withstanding the attempts of "modern" dietary concept like low carb high fat diet, there is strong scientific evidence of failure to better clear performance. Nutrition and metabolism is not black and white. The diet of elite athletes not always meet recommendations for macronutrient intake and caloric value. Recently emerged field of microbiome study uncover principles how gut bacteria may beneficially or harmfully influence the metabolic efficiency and health of athlete. There is a need for better recognition of healthy nutrition with limited processing and change of chemical and physical properties of consumed food.

Key words: *metabolism, microbiome, food, health, performance*

Introduction

The ancient games of Greece were a religious festival to honor the gods. Stories from the Olympics and the names and descriptions of well-known ancient athletes along with their training and dietary rituals are among the most fascinating texts to survive from antiquity (Kieran, Daley, & Jordan, 1977). Much of the early writing on athletics was written, during the classical period of Greece, hundreds of years after the first Olympic Games. Possibly the best accounts of athletic diet to survive from antiquity.

Although current dietary survey data on athletes participating in Olympic Games are scanty, data on elite level athletes from several countries have revealed wide variations of energy consumption (Grandjean, 1997). Jokl (1964) showed that a lower national energy intake related to poor athletic results at the Olympic Games. He presented summary data that correlated national Olympic achievement with levels of energy consumption.

Despite common view on healthy nutrition of athletes a number of studies over the past 20 years have been published that generally suggest a higher frequency of eating disorders among athletes than among non-athletes. Participation in competitive sport has also been considered an important factor related to the development of eating disorders. Taken together, most studies have suggested that eating disorders are particularly prevalent in sports that emphasize leanness or low body weight. However, some studies suggest a similar or lower prevalence of eating disorders compared with controls or athletes at a lower competitive level. (Sundgot-Borgen, Torstveit, & Skarderud, 2004) assume athletes constitute a unique population and the impact of factors such as training, eating pattern, extreme diets, restriction of food intake and psychopathological profile among them must be evaluated differently from that among non-athletes. Because there is a high prevalence of eating disorders in elite athletes that may have serious lifelong consequences, they recommend that all elite athletes, particularly those competing in leanness sports, receive screening for eating disorders. Also, education about health and performance-related nutrition and body composition is needed (Sundgot-Borgen et al., 2004).

Currently the most of the studies identify the energy deficit based on differences between energy of consumed food and energy expenditure during rest and activity. However to accurately assess energy intake it is important to imply real nutrient resorption and lost through feces. There is a challenge to count the real caloric values of food passed in to stomach and intestines.

Methods

The paper is written as a theoretical study. Three literature searches on human studies within the past 30 years were performed during October–November 2015. The search identified clinical trials with the terms: 'consumption and energy expenditure of athletes' (n = 35). Ten articles were excluded for the following reasons: irrelevant outcome (n = 2), only abstract available in English (n= 2), abstract not available (n=4). Two studies were excluded as being irrelevant to the outcome of interest (gut intestinal disorders n=2).

Resting energy expenditure in case studies presented in this lecture was obtained when the determination was done in rest and in the conditions described for the metabolic basal rate but after overnight fasting, including therefore the energy used for the biological utilization of the food (Blasco Redondo, 2015) (Amorim, Byrne, & Hills, 2007). Respiratory variables continuously measured using breath-by-breath gas analyzer systems power Cube (Ganshorn, Germany). Systems were calibrated prior to each session. At least two exercise physiologists supervised the testing procedures during the entire period.

Total daily energetic expense was assessed by wearing heart rate system. The heart rate monitor (Forerunner 620, Garmin International Inc., Olathe, KS) was attached to a strap on the torso of the subject.

Recording food intake and nutrition monitoring was previously set as a relevant method to gain an overview of factors influencing health (Rusin, Arsand, & Hartvigsen, 2013). For the reason to assessed energy intake from consumed food we used software Planeat (Slovakia).

Results and Discussion

Energy intake of ancient athletes

In the first century AD, Epictetus warns his readers that if they wish to succeed as athletes they must observe restraint in their eating and avoid rich confectionery (Harris, 1966). Xenophon tells us that they kept off bread; clearly they realized the dangers of too much starch. The fighting events were the most popular events with spectators, and for this reason Greek writers, when they speak of athletes, are often referring only to boxers or wrestlers. This is important where statements are made about diet. Much of our evidence clearly relates to the eating habits of these heavyweights, whose needs were very different from those of sprinters or long jumpers (Harris, 1966).

Nevertheless, relate to Milo of Croton, a wrestler whose strength became legendary. He was an outstanding figure in. the history of Greek athletics and won the wrestling event at five successive Olympics from 532 to 516 B.C. According to Athenaeus and Pausanius, his diet was 9 kg (20 pounds) of meat, 9 kg (20 pounds) of bread and 8.5 L (18 pints) of wine a day (Deipnosophists: 10:412:F; Description of Greece: 6:145).

However basic estimations reveal that if he trained on such a volume of food, Milo would have consumed approximately 57,000 kcal (238,500 kJ) per day (Grandjean, 1997). Although Milo was visibly a powerful, large man who possessed an extraordinary appetite, if all nutrients were resorbed, it could have store more than 1 kg of fat per day.

Energy gap of today's athletes

When comparing recommended dietary intakes for populations or to specific sport nutrient guidelines, there is a number of dietary investigations of Olympic and other elite-level athletes that interpret the intakes of energy and nutrients (Ziegler, Nelson, Barratt-Fornell, Fiveash, & Drewnowski, 2001; Hinton, Sanford, Davidson, Yakushko, & Beck, 2004;Heaney, O'Connor, Gifford, & Naughton, 2010; Burke, Gollan, & Read, 1991; Burke et al., 2003).

Though previous studies have found that male (Fudge et al., 2006; Onywera, Kiplamai, Boit, & Pitsiladis, 2004) and female (Muia, Wright, Onywera, & Kuria, 2016; Gibbs, Williams, & De Souza, 2013)athletes to be in negative energy balance during training and prior to competition.

Fudge et al. (2006) in their study assessed energy balance in nine elite Kenyan endurance runners during heavy training. Energy intake and expenditure were determined over 7 d using weighed dietary intake and doubly labelled water, respectively. Athletes were on average in negative energy balance (mean energy intake 13 241 ± 1330 kJ/d v. mean energy expenditure 14 611 ± 1043 kJ/d; P=0.046), although there was no loss in body mass (mean 56.0 ± 3.4) kg v. 55.7 ± 3.6 kg; P=0.285). The diet was high in carbohydrate (67.3 ± 7.8 %) and sufficient in protein (15.3 ± 4.0) %) and fat (17.4 ± 3.9 %). These results confirmed previous observations that Kenyan runners are in negative energy balance during periods of intense training.

Martin et al. (2002) estimated self-reported energy intake (EI) and cycling energy expenditure (CEE) during racing and training over 26 days for 8 female members of the Australian National Training Squad. Although there was a relationship between average CEE and average EI over the 26 days, not all cyclists modulated EI based on CEE.

As mentioned previously the prevalence of eating disorders is higher in female athletes than in male athletes (Sundgot-Borgen & Torstveit, 2004). However as comes from results of the review by Gibbs et al. (2013) a relatively small percentage of female athletes (0%-15.9%) exhibited all three Triad conditions (nine studies, n = 991). The female athlete triad is a syndrome linking low energy availability with or without disordered eating, menstrual disturbances, and low bone mineral density in exercising women. This problem gives rise to some interesting question. How much energy deficient they really are?

Mathematical modeling of food energy and Microbiota

It has been estimated that the microbes in our bodies collectively make up to 100 trillion cells, which is ten-fold the amount of human cells (Ley, Peterson, & Gordon, 2006). The majority of microorganisms resides in the gut, have a strong influence on human physiology and nutrition and are crucial for human life and health (Hooper, Midtvedt, & Gordon, 2002). Furthermore, the gut microbes contribute to energy harvest from food, and changes of gut microbiome may be associated with bowel diseases or obesity (Ley, Turnbaugh, Klein, & Gordon, 2006; Turnbaugh et al., 2006).

The gut microbiome can be viewed as a “microbial organ”—one that is sensitive to environmental, dietary, and host factors—with its functions intricately intertwined with host physiology and pathophysiology (Maruvada, Leone, Kaplan, & Chang, 2017).

De Filippo et al. (2010) compared the fecal microbiota of European children and that of children from a rural African village of Burkina Faso, where the diet, high in fiber content, is similar to that of early human settlements at the time of the birth of agriculture. Microbiota coevolved with the diet of Burkina Faso individuals, allowing them to maximize the energy intake from indigestible components, such as plant polysaccharides, by producing high levels of SCFAs that supply the host with an additional amount of energy. Given that enhanced ability to obtain energy-rich food is considered to be one factor that has driven human evolution. Thus the modulation of human microbiota during diet patterns allows to harvest more energy from otherwise non digestible sources as from fiberof African children or seaweed of Japan's sushi (Cian, Drago, Sánchez de Medina, & Martínez-Augustin, 2015; Jimenez-Escrig, Gomez-Ordonez, & Ruperez, 2011).Taking into account athletes who restricts energy intake, could modify microbiota to increase energy harvest from. It is well documented that obese patient's and anorexic patients have higher concentration of certain bacterial species to control (Armougom, Henry, Vialettes, Raccah, & Raoult, 2009; Million et al., 2013).

Each bacterial species within the gut aims to increase its own fitness, habitat, and survival via specific fermentation of dietary nutrients and secretion of metabolites, many of which can influence host appetite and eating behavior by directly affecting nutrient sensing and appetite and satiety-regulating systems. These include microbiota-produced neuroactives and short-chain fatty acids. In addition, the gut microbiota is able to manipulate intestinal barrier function, interact with bile acid metabolism, modulate the immune system, and influence host antigen production, thus indirectly affecting eating behavior(van de Wouw, Schellekens, Dinan, & Cryan, 2017). Consequently the net energy availability derived from food consumption is not only influenced by macronutrient content.In addition to dietary habits, described previously, moreover factors like circadian clock (Mukherji, Kobiita, Ye, & Chambon, 2013;Thaiss, Nobs, & Elinav, 2017), fitness level (O'Sullivan et al., 2015) and overall fatigue, mood disturbances, under performance and gastrointestinal distress which are common among athletes during training and competition (Clark & Mach, 2016). A growing body of evidence indicates that there is a crucial role for the microbiota in regulating different aspects of eating-related behavior, as well as behavioral comorbidities of eating and metabolic disorders (van de Wouw et al., 2017).

Petersen et al. (2017) in their pilot study examined what organisms are both present and active in the gut microbiomes of both professional and amateur level competitive cyclists and to determine if any significant differences exist between these two groups. These data suggest how certain organisms such as Methanobrevibactersmithii may beneficially influence the metabolic efficiency of the gut community in professional cyclists due to synergistic metabolic cross-feeding events.

Diet is known to dramatically modulate the composition of the gut microbiota. Due to the considerable complexity of stress responses in elite athletes (from leaky gut to increased catabolism and depression), defining standard diet regimes is difficult. What is troubling is that dietary recommendations for elite athletes are primarily based on a low consumption of plant polysaccharides, which is associated with reduced microbiota diversity and functionality (e.g. less synthesis of byproducts such as short chain fatty acids and neurotransmitters). As more elite athletes suffer from psychological and gastrointestinal conditions that can be linked to the gut, targeting the microbiota therapeutically may need to be incorporated in athletes' diets that take into consideration dietary fiber as well as microbial taxa not currently present in athlete's gut (Clark & Mach, 2016).

Summary

Athlete's nutrition in terms of assessment of energy intake and expenditure in is not black and white. The diet of elite athletes not always meet recommendations for macronutrient intake and caloric value. Consequently the net energy availability derived from food consumption is not only influenced by macronutrient content. The modulation of human microbiota during diet patterns or food restriction allows to harvest more energy. Most likely athletes who restrict energy intake, could modify microbiota to increase energy harvest from otherwise non digestible sources as from fiber.However partially due to new topic, more studies are needed to better understand the role of athlete gut microbiome to promote performance and overall health.

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EXAMINATION OF AUTONOMIC NERVOUS SYSTEM ACTIVITY IN HEMATOONCOLOGICAL PATIENTS

Hrnčiříková Iva, Kapounková Kateřina, Struhár Ivan, Janíková Andrea, Malá Alexandra, Svobodová Zora, Dovrtělová Lenka, Stejskal Pavel, Rašovský Adam
Masaryk University, Faculty of Sports Studies, Brno, Czech Republic
Faculty Hospital Brno, Hematooncology Clinic, Brno, Czech Republic

Abstract

Purpose: The aim of the study was to obtain information about autonomic nervous system (ANS) activity in hematooncological patients in remission before and after the interventional exercise programme through spectral analysis of heart rate variability (HRV). Patients with hematooncological diseases during and after treatment suffer from a number of side effects that aggravate their quality of life. The most common symptom is fatigue which may persist for years after the treatment has ended. The ultimate consequences of fatigue are the limited ability to exercise or to execute a basic mental activity. It is shown that exercise activity in patients with a hematooncological disease can greatly help to reduce fatigue.

Methods: The research file consisted of 10 persons of age 57,2 with ± 10,12.The spectral analysis of the heart rate variability was monitored in the tested patients before and after the three-month interventional motion programme. The non-invasive method of assessing the functional state of the autonomic nervous system was used to assess the effectiveness of the movement intervention by the use of spectral analysis of heart rate variability. The interventional motion programme ran for three months. The programme took place three times a week and lasted 60 minutes. The programme was composed of cardio training, strength training and breathing exercises. The results of the spectral analysis of heart rate variability showed significant positive changes in the autonomic nervous system in the tested group which underwent an interventional motion programme as opposed to a group of patients which did not take part in the programme.

Results: The results of the spectral analysis of the heart rate variability demonstrated significant positive changes in the autonomic nervous system of the group of patients that underwent the interventional motion programme in comparison to the group of patients that did not participate in the programme.

***Key words**: cancer, hematooncological diseases, autonomic nervous system, heart rate variability, exercise*

Introduction

Annually, about 80,000 patients with malignant neoplasm are diagnosed in the Czech Republic. New patients diagnosed with Hodgkin's lymphoma are approximately 260 and non-Hodgkin's lymphoma are 1400. In comparison to the world, the Czech Republic ranks 39th with non-Hodgkin's lymphoma and 26th with Hodgkin's lymphoma. Although mortality in recent years has decreased in both diagnoses, hematooncological diseases and their treatment have been shown to have many side effects that aggravate patients' quality of life. The most common side effect is enormous fatigue that accompanies the patient's subjective state not only during the therapy but it may persist for months or years after the termination of the therapy. This fatigue is a state of the organism that is characterized by extreme exhaustion and a reduced capacity for a physical and a mental work. Patients are often unable to undertake basic daytime activities. The overall impact can be not only reduced physical fitness but also significant changes in the body composition resulting in reduced body mass. Physical activity may be safe and well tolerated in patients with hematooncological diseases and demonstrates a great potential for reducing fatigue. It appears that fatigue associated with malignant tumours has a negative relationship with the overall autonomic nervous system (ANS) activity due to its dysfunction. It is known that the autonomic dysfunction in hematooncological patients is associated with a higher mortality rate in a cardiovascular disease and with a sudden death based on cardiac arrhythmias. However, the basic question is whether it is a paraneoplastic manifestation or the consequence of chemotherapy. Recent studies have shown that the autonomic function disorder in hematooncological patients is unlikely to be the result of chemotherapy, but a direct consequence of the disease or other, to this point, unrecognised factors.

Methods

File: The study group (Group 1) consisted of 10 subjects (average age 57.2 +/- 10.2 years) with Hodgkin's lymphoma or non-Hodgkin's lymphoma diagnosis. The subjects were 1 month, at most 3 months after the end of chemotherapy treatment. The subjects were sent from the Department of Oncology of the FN Brno. The control group (Group 2) was composed of 10 people (average age 58.2 +/- 6.41 years). The control group was also represented by patients with Hodgkin's lymphoma or non-Hodgkin's lymphoma. They were also 1-3 months after the end of chemotherapy treatment and they were sent from the same hospital. The group 1 underwent a 3-month interventional exercise programme. Before and after the 3-month interventional exercise programme, spectral analysis of heart rate variability (HRV) and the body composition using BIA was monitored. The study was approved by the University ethics committee (Masaryk University, Czech Republic) and in addition, each participant signed a written informed consent form.

Before and after the 3-month interventional exercise programme, spectral analysis of the heart rate variability (HRV) and body composition using BIA was monitored.

Measurements: The spectral analysis of the heart rate variability

The spectral analysis of the heart rate variability is a non-invasive method that is used to assess the ANS functional status through heart rate changes using a simple orthostatic test. The HRV analysis is based on the assessment of the fluctuation of intervals between normal, consecutive cardiac contractions, most often between R waves. The spectral performance of the HRV is influenced by a range of internal and external stimuli. The most significant are the influence of age and some chronic diseases affecting the ANS function. Therefore, a simple hypothesis is that a particular disease affects the ANS performance negatively. (Stejskal, Schlacht, Elfmark, Salinger, Gaul-Alacova, 2002, pp.13-18). The essence of the spectral analysis is the distribution of the irregular course of the HRV to regular cycles which represent the processes influencing its variation. Since both reciprocal control subsystems, sympathetic and parasympathetic, "work" with different frequencies (parasympathetic "responds" more quickly, sympathetic reacts slower, probably due to different characteristics of their neurotransmitters), it is possible to statistically differentiate them and quantify their so-called "spectral power". When analysing the HRV frequency spectrum, the sympathetic effect (with a partial parasympathetic fraction) is assumed to be within the range of frequencies of 0.04-0.15 Hz (so called low frequency band, LF) and the parasympathetic representation in the range of 0.15 to 0.40 Hz so-called high frequency band, HF). Heart rate is not an isolated variable but it is closely related to blood pressure, breathing, and other factors. Therefore, it is always necessary to interpret HRV results in relation to the overall clinical status or treatment. The HRV was measured using the VarCor PF5. The data were obtained from a short-term ECG record of 300 beats (minimum of 5 minutes). The device allows the telemetric transmission of modulated signal (i.e. the length of the R-R intervals from the ECG recording with 1ms accuracy) to the computer processing. The results of SA HRV have been measured by a standard method (orthoclinostatic test) using short-term recording in the positions "lying down" – "standing up" – "lying down". The first "lying down" position is used to standardise the measurements. During the "standing up" position, the orthodontic stimulation of sympathetic is concluded. And clinostatic stimulation of vagus is induced in the last "lying down" position. In the study, frequency range of

20 to 500 mHz, which divides into three spectral components, was observed: VLF (very low frequency) - very low frequency in the range of 20 to 50 mHz with the frequency of 0.6 to 3 periods per minute; LF (low frequency) - low frequency in the range 50 to 150 mHz with the frequency of 3 to 9 periods per minute; and HF (high frequency) - high frequency in the range of 150 mHz and higher with the frequency of 9 or more periods per minute. To evaluate SA HRV, the following methods were used: a) standard performance indicators of individual frequency components (PVLF, PLF and PHF), where PHF is exclusively under the influence of vagus nerve activity, while PVLF and PLF are affected by both ANS subsystems; b) Comprehensive indicators - Total Score (CS), Complex Vagus Nerve Activity Index (VA), Comprehensive Sympathetic Bamance Index (SVB) and Age Standardised Total Spectral Performance (PT) (18). The complex parameter values are expressed in points, normal CS values are between +1.5 and -1.5 points, while VA, SVB and PT have a normal range of +2.0 to -2.0 points.

A spiroergometric examination

A spiroergometric examination was used to measure cardiovascular fitness. A weight-of-peak exercise test was used on an ergometer using ECG curve and blood pressure changes during physical activity. Maximum Oxygen Uptake (VO2max) was found before and after of the experimental protocol on a cycle ergometer (Lode Excalibur). The maximum heart rate was determined in the laboratory using a stepped load test on a bicycle ergometer.

Composition of the body bioelectric impedance

The bioelectric impedance method (InBody 230) was used to evaluate the body composition, which is a validated method with wide application in practice in the measurement of the common population. Bioelectric impedance is a method for determining the amount of lean body mass (LBM). It is based on the measurement of body resistance to alternating electrical current, where the resistance depends indirectly on the amount of body water.

Interventional exercise programme

The interventional exercise programme had run for three months. The programme included cardio training, strength training and breathing exercises. The training lessons were conducted three times a week and consisted of 30 minutes of aerobic exercises, 15 minutes of muscle strengthening exercises and 10 minutes of stretching. The intensity of the exercise was set individually by each patient separately based on an input stress test, and 70-75% of the maximum pulse rate.

Statistics

All statistical analyses were performed using the Statistica 12.0. Data are presented as means with standard deviation. Paired t-test for dependent samples was used to data analyses.

Results

The results of spectral analysis of heart rate variability showed positive changes in the autonomic nervous system in the group of patients who underwent the interventional motion programme (Group 1) as opposed to the control group (Group 2) that did not participate in the programme.

Group 1 patients were examined after three months of the movement training. The median sympathetic vagal balance was observed from -0.22 to 0.33 ($p = 0.023$), as well as positive changes in vagotonia, where the median rose from median -1.92 to -1.55 ($p = 0.03$). Group 2 patients showcased no significant change in both the sympathetic vagal balance level, where the median increase was from -1.8 to -0.3, and in vagotonia with a median increase from -1.8 to -1.13.

Changes were also manifested in the body composition. For probands in Group 1, the median BMI decreased from 28.5kg.m-^{2} to 28.2 kg.m-^{2}, The median amount of fat component dropped from 29.9 kg to 29.6 kg, and the median amount of active body mass increased from 38, 1kg to 38.3kg. As for probands in Group 2, the median BMI increased from 27.8 kg.m-^{2} to 28.1 kg.m-^{2}, the median fat component increased from 28.4 g to 28.9 kg, and the median share of active body mass fell from 38.6kg to 38.3kg.

Discussion

It appears that fatigue associated with oncological diseases has a negative effect on the overall ANS activity, especially the vagal activity. It is also contemplated that HRV is associated with chronic inflammation, which increases the persistence of fatigue in survivors with cancer. (Dupont, Bover, Ganz, 2012). Subclinical dysfunction of the autonomic nervous system is frequent in Hodgkin's lymphoma patients and is likely to represent paraneoplastic syndrome (for Hodgkin's lymphoma, approximately 50% of patients were diagnosed with cardiovascular neuropathy and 30% with HRV reductions). (Turner, Bolant, Parker, Ewing, 1993, pp.623-626).

It seems that fatigue associated with malignant malignancies has a negative relation to the overall ANS activity, in particular to vagus nerve activity; it is contemplated whether the lower HRV is associated with chronic inflammation that increases the persistence of fatigue in cancer survivors (Dupont A, Bower JE, Ganz PA., 2012; 3.2). This phenomenon may predispose patients with lymphoma to emergence of gastrointestinal and genitourinary dysfunctions or postural hypotension. And according to some authors, this phenomenon cold be included in the evaluation of neurotoxic chemotherapy regimens (Turner, Bolant, Parker, Ewing, 1993, pp.623-626). It is known that autonomic dysfunctions in lymphoma contribute to higher mortality rates from cardiovascular disease and sudden death based on cardiac arrhythmias. However, the basic question is whether it is a paraneoplastic manifestation or the consequence of chemotherapy; in the first case, chemotherapy could help treat this alteration, in the latter case chemotherapy may be the cause of exacerbation of autonomic dysfunctions. Recent studies seem to indicate that a disorder of autonomic functions in lymphoma is not likely to be the result of chemotherapy but a direct consequence of the disease or other unrecognised factors; autonomic neuropathy may therefore be considered a paraneoplastic disease (Bilora F, Veronese F, Zancan A, Biasiolo M, Pomerri F, Muzzio PC, 2010; 2 (1)). Regular exercise is known to increase physical fitness and to cause positive changes in ANS, in both, patients and healthy subjects (Boullosa DA, Abreu L, Leicht AS, 2012; 44: p.636-p.636).

Medium intensity aerobic exercises have an effect on changes in body composition and on the increase in body mass (Devin, Sax, Hughes, Jenkins, Aitken, Chambers, Dunn, Bolam, Skinner, 2016, pp 467-479).

Conclusion

Based on the results, we conclude that combined moderate intensity training programme is feasible and despite its short duration, brings measurable positive results in hematooncological patients treated with intensive regimes.

At present, controlled physical activity (PA) is a current and crucial part of supportive care in haematological and other oncological diseases. It increases the resistance to enormous fatigue, it increases cardio-respiratory performance and muscle strength, it improves physical well-being, it reduces anxiety and depression, and it improves in particular the quality of life in the broadest sense. This knowledge leads to specific PA indications during the disease and after its successful treatment (in the sense of remission). The prescribed and long-term PA must be sufficiently intense in order to exceed the minimum intensity, frequency, and duration which are required to achieve a significant benefit. This, however, means defining precisely the context of clinical management of these patients through individual correct prescription of the PA programme to a particular patient in a given clinical condition. There is still an open scientific question regarding the most effective types of PA in terms of their influence on the health of surviving hematooncological patients and regarding the type of PA which could be efficiently implemented to conditions at patients' homes. To answer these questions, the endurance and strength abilities, autonomous nervous system activity and body composition will be continuously examined. In addition, the change in psychological parameters of quality of life, anxiety and depression will also be assessed. In the different phases of the project, movement and nutrition interventions will be gradually modified the most effective individualised combinations can be recommended in the final design. This recommendation will be formulated based on guidelines (such as Physical Activity and Nutrition Guidelines for Cancer Survivors) that can serve healthcare insurance providers to create specific criteria for secondary prevention and the provision of supportive therapy in hematooncological patients. The systematic implementation of this care will significantly reduce the cost of therapy of remission patients and it will improve their quality of life.

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HYDRATION FOR BETTER PERFORMANCE – AUTONOMOUS OR PRESCRIBED DRINKING REGIME?

Kumstát Michal, Kapounková Kateřina, Dovrtělová Lenka
Faculty of Sport Studies, Masaryk University, Brno, Czech Republic

Abstract

The amount and way of fluid administration during exercise and consequent changes in body weight are now being challenged in scientific literature. A contrasting debate between scientists supporting either the autonomous or prescribed model of fluid intake is escalating. Currently accepted guidelines, taken from the American College of Sport Medicine position stand published in 2007, favour an individually prescribed fluid intake regime with the aim of eliminating the negative effects of hypo-hydration on the athlete's performance and health. The use of the prescribed regime assumes the estimation of the sweating rate. Contrasting to the theoretical postulation, however, athletes usually autonomously regulate fluid intake either by physiological signals (e.g. thirst) or they simply drink at any time and in any quantity (ad libitum). Based on the growing scientific evidence, autonomous hydration strategies may not reduce performance, even endurance-based in warm environment. The aim of the theoretical review is to discuss the two contradictory in-exercise fluid intake strategies in relation to the athlete's performance. The original studies, reviews, and meta-analyses that either support or oppose currently accepted drinking guidelines were searched and included using the PubMed, Google Scholar and Sport Discuss.

***Key words**: athletes, dehydration, endurance, fluid intake, physical activity.*

Introduction

In the last 20 years, it has been postulated that the exercise induced weight loss impairs athletic performance. Recommendations published in 1996 by the American Society of Sport Medicine (ACSM) stated the following: "athletes should drink as much as they can tolerate or in the amount that would compensate for individual sweat loss" (Convertino et al., 1996). In other words, dehydration was considered undesirable. In its latest document ACSM moderately revised previous recommendation and slight dehydration equivalent to ≤ 2 % body weight loss has been found tolerable (Sawka et al., 2007). A number of sports organizations and associations (e.g. IAAF[1], FIFA)

[1] IAAF, International Association of Athletics Federations; FIFA, Fédération Internationale de Football Association

followed ACSM recommendations in their official documents (Burke, Maughan, & Shirreffs, 2007). The recommendations are principally based on the knowledge of individual sweating rate and sweat loss estimates induced by exercise and thus favours the so-called individually controlled (prescribed) fluid intake regime. The aim is to maximally eliminate the negative effects of hypo-hydration on performance and health of the athlete.

In the daily training routine most athletes, the fluid intake is however regulated by the athlete's own feelings, that is, the dictation of thirst or ad libitum fluid intake where an athlete drinks at any time and in any quantity. The concept of autonomous (e.g. ad libitum and/or thirst-controlled) fluid intake challenges the prescriptive regime and contradicts the thesis of dehydration as a performance impairing situation. According to growing body of evidence, ad libitum and/or thirst-controlled fluid intake sufficiently prevents the athlete from a level of dehydration that impairs performance (Noakes, 2010). In contrast, the opponents state, that the autonomous model does not compensate for the exercise induced water losses and its formal acceptance is not possible (Armstrong, Johnson, & Bergeron, 2016b).

Therefore, at present, there is an intense debate originated from supporters of the autonomous fluid intake regime (Hoffman, Cotter, Goulet, & Laursen, 2016). This is however contradictory to the present guidelines that are based on prescriptive fluid intake regime (Armstrong, Johnson, & Bergeron, 2016a). The aim of the theoretical review is to discuss current in-exercise fluid intake strategies, specifically the prescriptive and autonomous, in relation to the athlete's performance.

Methods

It is difficult to address a consensus in the field of hydration in sport, because currently emerging attitudes of sport medicine experts to the fluid intake during exercise are contrasting. Reviews and meta-analyses papers that oppose currently accepted drinking guidelines (Noakes, 2010; Goulet, 2011; Goulet, 2013; Cotter et al., 2014; Hew-Butler et al., 2015; Hoffman, Cotter, Goulet, & Laursen, 2016) were included in order to form the critical basis for the discussion. As a guideline, a pivotal work titled "*American college of sport medicine position stand: Exercise and fluid replacement*" (Sawka et al., 2007) has been chosen. Our choice was supported by the fact that International Olympic Committee refers to the ACSM in its latest guidelines (Maughan & Shirreffs, 2011). Original studies (published from 2010) investigating the association between in-exercise fluid ingestion, performance and a way of fluid administration were searched and included. All papers were searched using the PubMed, Sport Discuss, Google Scholar databases entering following keywords: ad libitum, hydration, fluid-intake, sport performance, thirst, dehydration, endurance performance, exercise and/or hypo-hydration.

Dehydration level and sport performance

According to recent meta-analyses, the 2 % concept does not have such deteriorating impact on performance as previously considered (Goulet, 2011). Furthermore, the results of many studies presented in the last decade completely refute currently accepted recommendations and lead to their questioning (Wall et al., 2013). A greater exercise induced weight loss in many sports disciplines (distance running, cycling), is positively associated with overall performance (Hoffman, Hew-Butler, & Stuempfle, 2013). The correlation between the exercise induced body weight loss and the finishing time has been documented in marathon (Zouhal et al., 2011), during the 6-day trail running race in tropical conditions (Hue, Henri, Baillot, Sinnapah, & Uzel, 2014) or even in 3 km running distances (Adams et al., 2016).

An earlier retrospective study calculated the level of dehydration of the top 5 men and women in Athens Olympic marathon 2004 at the level of 4-9 % (Rooyen, Hew-Butler, & Noakes, 2010). Beis, Wright-Whyte, Fudge, Noakes, & Pitsiladis (2012) confirm these findings by showing large inter-individual variability of fluid intake (0.03-1.09 L/h) in the elite marathon runners (~ 2:06). Estimated level of dehydration (=body weight loss) was based on a calculated sweating rate and fluid intake and reached 6.6%-11.7%. Despite the fact that the average observed intake (0.55 ± 0.34 L/h) corresponds with the current ACSM recommendations for the fluid intake during exercise (0.4-0.8 L/h), the estimated body weight loss are under relatively favourable climatic conditions of ~ 15 ºC were completely beyond the scope of the recommendations adopted by the same institution. The dehydration of 9.8 % by the winner in Dubai marathon 2009 (H. Gebreselasie) has been presented (Beis et al., 2012). These realistic examples illustrate that the endurance performance achieved by elite athletes often at high ambient temperatures (increasing the risk of dehydration) is close to the absolute best performance achieved even under significantly more favourable weather conditions (reducing the risk of dehydration).

The question, how is it possible that endurance performance in extreme environmental conditions are approaching the Olympic records and the best world performances, can be formulated. Aren't we overestimating the actual impact of dehydration on performance which is probably less serious than the laboratory studies are saying?

Methodology issue?

The methodological aspects of former studies supporting the 2 % rule are being criticized. Goulet (2013) particularly emphasizes the fact that athletes in former experiments were not exposed to situations that replicate the real sport conditions. In particular, a fixed work-load is criticized (usually tests to exhaustion with clamped intensity), the absence of environmental conditions (wind, temperature, sunshine) and, above all, the blindness of study participants to the level of hydration. As such earlier experiments not always taking these factors into account confirm the limit of 2 % of dehydration as critical to maintain optimal performance (Sawka et al., 2007). Based on the assumption, that athletes follow self-paced strategies, Goulet (2013) proposed to distinguish between an ecologically valid (using predominantly the time-trial testing) and non-ecologically valid (fixed-clamped work load) experiments. The impact of dehydration that equals body weight loss up to ≤ 4 % induced by ecologically valid experiments has not been shown to impair endurance athletic performance.

The absence of blindness to the level of hydration is an example of non-ecologically valid research. Wall et al. (2013) induced 3 % body fluid deficit in a group of 10 trained cyclists by the 2-h submaximal dehydration test and subsequently re-infused them with saline to replace either 100 %, 33 % or 0 % losses so that before the experimental test (25 km time-trial, 33 ºC, wind speed 32 km/h) cyclists were hypo-hydrated by 0, 2, or 3 %. During the experimental test, the saline was infused in an amount equal to the sweat losses. This procedure ensured that participants were not aware of one's individual state of hydration. The results corresponds with the recent meta-analyses and questioned the 2 % limit, because in addition to the rise in rectal temperature (+ 0.3 °C), no differences in performance were found between the experimental situations.

Most sport hydration research is carried out in endurance setting (typically running, cycling). Subsequent recommendations are then replicated into a broad sporting environment, which cannot be always appropriate. For example Nuccio, Barnes, Carter, & Baker (2017) conclude that the knowledge about the effect of dehydration on the cognitive and specific-skill performance in team sports is totally absent.

Autonomous drinking regime – thirst driven and ad libitum

Thirst driven strategy

Fluid intake according to the thirst sensation among the other hydration approaches is associated with the highest level of dehydration. Dion, Savoie, Asselin, Gariepy, & Goulet (2013) showed that the programmed fluid intake (1.380 ± 320 mL/h) significantly differ from thirst-controlled fluid intake (384 ± 180 mL/h) during half marathon in the heat. Despite the fact that programmed (prescribed) fluid intake reduced the dehydration level from 3.1 to 1.3 % compared to the thirst driven intake, the performance did not differ. This supports the uncertainty about the 2 % dehydration limit. Thirst is a defensive physiological response to the body fluid deficit and is dictated by a complex of physiological stimuli (plasma osmolality and volume) and other variable environmental, social, sports-related factors.

Former recommendations made us drink before thirst develops. This, however, in many (especially recreational) individuals may paradoxically lead through anxiety about inadequate fluid intake to the intake at rates that exceeds the sweat losses. This awareness may consequently resulted in over-hydration increasing the risk of developing hyponatraemia (Hew-Butler et al., 2015). According to Noakes (2007), Cotter et al. (2014) and many others we have been adequately adapted to compensate for fluid losses by thirst-driven drinking regime in rest and even during physical activity without any negative health consequences. Additionally, the recent consensus statement suggests that excessive hypotonic fluid intake, above exercise induced water losses is considered to be the most compelling etiological factor in the development of hyponatremia (Hew-Butler et al., 2015). Thirst-controlled fluid intake strategy has been recommended in ordered to prevent an athlete from over-drinking and eliminating the risk of developing hyponatremia. Armstrong et al. (2016b) however argue, that there is no study that would in fact verify whether the intake based on thirst really reduces the risk of developing hyponatremia.

Similarly a meta-analysis by Goulet (2013) conclude that the intake of fluids controlled by the thirst for most top and recreational athletes does not lead to dehydration level that reduces the performance. There are situations in which drinking according to thirst should be considered carefully and should be replaced by ad libitum or prescribed drinking regime: sport events with high expected rate of sweating, twice a day workouts, unacclimatized and/or older athletes, ultra-distance events under high ambient temperatures (> 30 ºC) or situations whit limited options for fluid intake (water stations in race events) (Cotter et al., 2014).

Ad libitum strategy

One can understand drinking according to thirst as ad libitum, others may drink after they perceive thirst or in order not to experience thirst. The thirst-driven drinking regime can be therefore interpreted differently which may definitely modify subsequent intake. Ad libitum is generally more liberally understood as unlimited intake, anytime and in any quantity. There is however no formal agreement on the definition of ad libitum fluid intake or intake according to thirst (Armstrong et al., 2014). Cotter et al. (2014), in recent review, stated that the risks of performance-limiting level of dehydration are insignificant in all individuals (athletes) having ad libitum access to water and fluids. According to the authors, ad libitum fluid intake is a sufficient strategy for most sports activities, in the vast majority of different environmental conditions. A performance of well-trained and acclimatised athletes during 6-day ultra-endurance performance in tropical conditions was not compromised by drinking ad libitum. Moreover ad libitum strategy did not lead to overheating or substantial dehydration (Hue et al., 2014).

Ad libitum fluid intake in athletes who underwent 20 km run in the heat (28 ºC) resulted in a 2.6 % decrease in body weight compared to customized prescribed intake (1.3 %). Prescribed regime resulted in more than 2x higher fluid intake (1700 ml vs. 750 ml) and lead to 64 % vs. 30 % replacement of total water losses compared to ad libitum regime. Again, in terms of performance, there were no differences between the fluid strategies chosen (Lopez et al., 2016).

It seems to be prudent to validly define drinking according to thirst since it may by highly misinterpreted. Moreover, formally separating thirst-driven regime from ad libitum may prevent athletes from viewing them interchangeably.

Prescribed drinking regime

An estimation of sweat losses needed to customize fluid replacement during exercise is the principal of the prescribed drinking regime (Convertino et al., 1996; Maughan & Shirreffs, 2011; Sawka et al., 2007; Armstrong, Johnson, & Bergeron, 2016a). To apply such strategy the knowledge of the body weight changes accounting for urinary losses and drink volume is needed for estimation of individual sweating rate. From the practical point of view, applicability of this model is due to highly variable environment extremely difficult. Athletes are "forced" to keep records and regularly monitor pre- and post-exercise body weight for exercise of varying duration and intensity held under different conditions. Regular monitoring of fluid balance is the only way to obtain information needed for proper fluid intake prescription (Armstrong et al., 2016b). Most importantly an individual athlete responsibility to follow the correct measurement methodology is critical for obtaining correct data. For example the use of an electronic nutrition diary of an athlete may be useful and practical tool (Kočař, 2017). Prescribed intake may interpreted as controlled dehydration in situations where an athlete, based on the knowledge of individual sweating rate, plans fluid intake so that the expected degree of hypo-hydration will not exceed a performance limiting level (e.g. 2-4 %).

There are a number of familiar reasons why the programmed fluid intake strategy to determine the required amount of fluid intake may be inaccurate, such as glycogen depletion (Maughan, Leiper, & Shirreffs, 1997). During the prolonged exercise, glycogen oxidation and related weight loss occur. At the same time, oxidation of 1 g of glycogen results in release of 3 g of water. The weight loss caused by the moderate-high intensity exercise therefore does not necessarily have to indicate dehydration and may lead to an overestimation of the planned intake (Tam et al., 2011). Erroneous sweat loss estimates, e.g. overdosing by 200 mL/h during 10-h prolonged activity (e.g. Ironman triathlon) may lead to 2L fluid overconsumption, increasing the risk of EIH.

A specific example of prescribed fluid intake is distance running in which a competitor is required to drink at predesignated refreshment stations (usually known number of stations). The case study by Kumstát, Rybářová, Thomas, & Novotný (2016) is a real sport example of a combination of prescribed (planned) intake (known number of stops to drink) and ad libitum fluid intake (free in amount) strategies that were successfully adopted during the FINA Swimming Grand Prix. Due to the circumstances of races lasting ~ 5-10 h and allowing refreshments according to their own plan (each competitor has his guide) the fluid intake was programmed every 15 minutes. This approach is in line with the conclusions made by Cotter et al. (2014) who suggest to plan the intake if risky conditions appear (ultra-distance event, high ambient temperature). It is therefore suggested to appropriately combine the hydration strategies according to the circumstances of the exercise in order to adjust the volume of fluid intake. On the contrary, individuals with a high sweating rate may/must tolerate larger amounts of fluid during activity in the heat and hence the perception of thirst may lead to insufficient compensation for water losses. Moreover, the more the training volume the greater the degree of sweating and the absolute loss of sweat. This significantly reduces the amount of effective water and sodium loss compensation (lack of time, access to fluids), and reliance on fluid intake according to the feeling of thirst may be also inadequate highly justifying prescribed regime.

Practical recommendations

The use of the prescribed regime assumes the knowledge of the body weight losses resulting in an estimation of the sweating rate. Sweating rate is used to individualize the fluid intake during exercise in order to limit the hypo-hydration that inevitably occurs. Following an autonomous fluid intake, in contrast, is either controlled by physiological signals (e.g. thirst) or is absolutely benevolent and an athlete ingests fluids ad libitum (at any time and in any quantity – depending on fluid accessibility). Appropriate hydration guidelines should by based on individually determined choice and are dependent on many variables. The known or unknown amount of fluid expected/planned to ingest during an exercise turns an athlete toward the selection of either autonomous or prescriptive strategy. Moreover if the sweating is expected to be high and prolonged (due to the extreme environmental condition, duration and intensity of an exercise) such as endurance exercise and simultaneously an accessibility to fluid intake is expected to be low, then prescriptive strategy would by of higher importance as it may prevent an athlete from undesirable acute or cumulative (multi-event/day race) water losses. In contrast, if the duration of an event not exceeds 1,5 - 2 h (vast majority of recreationally based sporting activities), an opportunity to drink (e.g. driven by thirst) should effectively compensate for water losses and may be adopted by majority of non-elite athletes.

There are however other exercise and non-exercise aspects that may affect subsequent fluid intake such as mode of exercise (training vs. competition), individual experience and habits, fluid characteristics (e.g. palatability, temperature and energy content), "non-fluid" nutrition contributed to the water intake, etc.

Conclusion

The theoretical work attempts to comment on the issue of in-exercise fluid intake. Based on the growing scientific evidence, thirst-controlled and/or ad libitum fluid intake are hydration strategies that may not reduce endurance-based high intensity performance, even in warm environment. Autonomous drinking strategies appear to be accepted alternatively to the formally recommended prescribed regime mainly in recreationally-sport setting.

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VERIFICATION OF LAG-TIME OF PELLETS WITH CONTROLLED RELEASE OF GLUCOSE DURING VARIOUS PHYSICAL ACTIVITIES

Růžička Ivan[1], Růžičková Kamila[1], Sabadková Dana[2], Pavloková Sylvie[2], Muselík Jan[2], Franc Aleš[2], Neumann David[3]

[1]Faculty of Education, University of Hradec Králové, Hradec Králové, Czech Republic

[2]Faculty of Pharmacy, University of Veterinary and Pharmaceutical Sciences, Brno, Czech Republic

[3]Faculty of Medicine of Charles University and University Hospital Hradec Kralove, Czech Republic

Abstract

Prevention of hypoglycemia is a obligation in physical activities of people with Type 1 Diabetes Mellitus (T1D). We used pellets with sequential release of glucose to prevent harmful need to eat in the course of physical exercise. The work verified the stability of 240minute lag-time of the pellets under the conditions of varied long-lasting physical activity in adolescents and young adults with T1D, using ^{13}C breath test. A systemic programme of specific physical activity to verify an impact of physical load and of aerobic/anaerobic and mixed exercise on the lag-time of pellets in real life. We designed a protocol of various forms and courses of motion within 3 consecutive days. The subjects′ responses to exercise were monitored by heart rate and continuous glucose monitoring, ^{13}C-glucose breath test was used to assess pellets behaviour during sport. Eight boys with T1D without chronic complications aged 13 to 20 years (weight 68.8±16.3 kg, height 173.5±11.5 cm, BMI 22.25±4.55 kg/m^2 were included in the study. Ruffier fitness test and the measurement of resting heart rate determined their physical readiness. Three-day programme graded in intensity consisted of atypical sports, activities with cognitive processes, speed-endurance motion with high physical and mental demands and with accented fluctuations in heart rate. Our study has shown the stability of the lag-time of the pellets under various physical activities of adolescents and young adults with T1D. The programme of physical activity traced the needs and accents of the research project.

***Key words**: Diabetes mellitus Type 1, physical activities, special needs, pellets with controlled release of glucose, functional food*

Introduction

Type 1 diabetes mellitus is characterized by a lack of insulin, leading to the inability to treat sugars as an energy source, to hyperglycemia and to metabolic disruption. An incorrect treatment leads to chronic complications and a shorter life. The cause is insulin deficiency because of autoimmune damage to the beta-cells of the islets of Langerhans in the pancreas (Chimen, 2012). Significant complications of treatment include hypoglycemia, a condition where, due to the predominance of externally administered insulin, lack of food or energetically unsecured motion, sugar is missing in the body. The manifestation of the lack of glucose in the CNS may be a disturbance of consciousness, unconsciousness or convulsions. In addition to the demands of managing the situations of everyday life, children, parents as well as teachers are exposed to the possibility to place a child with T1D into an active life, either regular recreational or performance physical activities (Edmunds et al, 2007). The essence of T1D treatment is to prevent glycemic upset. The impact of physical activity on persons with T1D has been examined by a number of studies which have shown a reduction in the incidence of complications with an optimum exercise regimen. The study by Pan et al. (1997) placed physical activities to the front place of preventive procedures for managing diabetes. An American meta-analysis has shown that regular exercise in persons with T2D reduces mortality compared to physically inactive persons; and a further study then the positive impact of regular exercise on the body and the quality of life of adults (Slentz et al., 2009; Chimen, 2012; Mikus et al., 2012) as well as children with diabetes (Riddell, & Iscoe, 2006; Hess-Fischl, 2017).

The precaution is to provide energy sources for the activity of persons with diabetes in a sufficient extent and with a functional way of delivery and subsequent use during physical activity. An innovative way of providing glucose for diabetics in an active lifestyle is the development of a pharmaceutical form with controlled release of glucose; by its nature, it enables the prevention of hypoglycemic states of sporting people (Franc et al., 2015; Neumann et al., 2017a). The development of pellets – a stable form of glucose protected by ethyl cellulose coating, which is also responsible for controlled predictable release – would, after being put into practice, help prevent hypoglycemia and allow for the reduction of the dose of standard carbohydrates taken by the patients ‘preventively’.

The aim of the work was to verify the stability of 240minute lag-time of pellets containing glucose in the conditions of varied long-lasting physical activity of adolescents and young adults with T1D by ^{13}C-clucose breath test.

Methods

The programme was part of the Pre-seed Project 2015 'Verification of lag-time of pellets with controlled release of glucose' (TG02010020-1, University Hospital Hradec Kralove). This project followed IGA MZ NT14479-3/2013 grant, aiming to verify the stability of previously designed pellets with controlled release of glucose under the conditions of various types of physical activity.

During the pharmaceutical development of the pellets, the national patent 'Farmaceutická kompozice s řízeným uvolňováním metabolicky aktivního cukru' (Pharmaceutical composition with controlled release of metabolically active sugar; WO 2014180453 A1; ÚPV - Czech Industrial Property Office 2013/338, 19. 11. 2014) and the international patent application 'Pharmaceutical composition with controlled release of metabolically active sugar' (ÚPV PCT 2014/000004, 13. 1. 2014; EP2994111A1, US 20160081941 A1) of the team of authors Franc, Muselík & Neumann were obtained.

Thus the research was carried out in two crucial phases: development and verification of lag-time pellets in vitro (laboratory work with dissolution proves) and verification of the effect of the physical load of heterogeneous character on lag-time pellets with controlled release of glucose in vivo using ^{13}C technology to make in vitro – in vivo comparison. We were involved in the second phase of the project.

A programme of structured physical activity was created enabling verification of the impact of physical load on 240minute lag-time of pellets containing glucose. The programme intentionally used various forms and courses of daily motion load with respect to the age of subjects as well as their physical readiness.

The study group consisted of 8 boys with T1D otherwise healthy 13-20 yr old, weight 68.8±16.3 kg, height 173.5±11.5 cm, BMI 22.25±4.55 kg/m^2. Subjects had not chronic complications of diabetes. Autoimmune conditions, if any, as autoimmune thyroidits and celiac disease were appropriately treated. Exclusion criteria included very poor glycemic control, acute illness and low physical condition.

The research methods mapping directly glucose metabolism and intensity of exercise consisted of ^{13}C-glucose breath tests for the subsequent verification of glucose metabolism and release from the body through exhaled $^{13}CO_2$, Ruffier fitness test to determine physical readiness of the body (before the start of the programe), selected Unifittest 6-60 (Cooper run, standing long jump and sit-ups – Kovář & Měkota, 1995) mapping selected motor abilities and varied movement activities based on motor conditions and load. The project was realized together by the pediatric diabetology team of University Hospital Hradec Kralove and the team of interdisciplinary experts of the Faculty of Education, University of Hradec Králové. The programme included three days of varied physical activities with graded intensity, using non-traditional sports and teambuilding games with more intensive physical dynamics, enabling involvement of subjects in activities and their distraction from physical load; activities with the involvement of mental processes in the performance, strong adrenaline experience and speed-endurance character with high physical and cognitive demands, with strong fluctuations of heart rate and a sustained endurance load with motor testing.

The physical activity intensity during testing was recorded by the heart rate measurement (American Heart Association, 2015), every 30 minutes by self-measurement controlled occasionally by members of the team. The lag-time of 240 minutes was examined by ^{13}C-breath test. The substrate, ^{13}C-glucose, undergoes a metabolic processing after absorption from the gastrointestinal tract with preset delay, and its fraction appears in exhaled breath as $^{13}CO_2$. The time point of elevation $^{13}CO_2$ reflects the lag time. Exhaled breath was collected in a series of 30 to 60 minute samples within 10 hours into plastic tubes (Neumann et al., 2017b). The analysis was done using mass spectrometry (Sercon, Ltd., UK) in the Department of Clinical Biochemistry and Diagnostics, Charles University in Prague, and University Hospital Hradec Kralove.

Results

Subject initial characteristics are in Table No 1:

Table 1. Subject body and fitness features

Subj No:		1	2	3	4	5	6	7	8
Age	*[yr]*	*13*	*13*	*17*	*14*	*14*	*16*	*20*	*15*
High	*[cm]*	*167*	*162*	*177*	*173*	*171*	*173*	*185*	*173*
Weight	*[kg]*	*57*	*52.5*	*84*	*56*	*57*	*60*	*85*	*53*
BMI	*[kg/m^2]*	*20.4*	*20.0*	*26.8*	*18.7*	*19.5*	*19.8*	*24.8*	*17.7*
Resting heart rate	[bpm]	60	60	56	68	80	68	80	68
Ruffier test	[index]	2.4	10.4	3.6	6.0	7.0	6.0	8.4	6.8

Physical activity varied and intensified as described in following section:

Day 1:

The programme was built on experiential team activities which enabled inclusion of all the subjects in movement activities, suitably distracted their attention from the load, offered positive motion experience and helped to bring the participants together. In this arrangement, the activities allowed a regular monitoring of functional parameters according to the project intention. The opening Ruffier test showed a variety in subjects' physical readiness for physical load. It was followed by the intake of glucose pellets, tiny beads mixed into yoghurts or just taken with a drink. Then a longer activity of moderate load followed (walking, 7 km/130 minutes, average value of heart rate 94 bpm corresponds to a slightly lower value of the whole day average). The programme continued with unconventional games Ringo and Indiaca on a beach volleyball court.

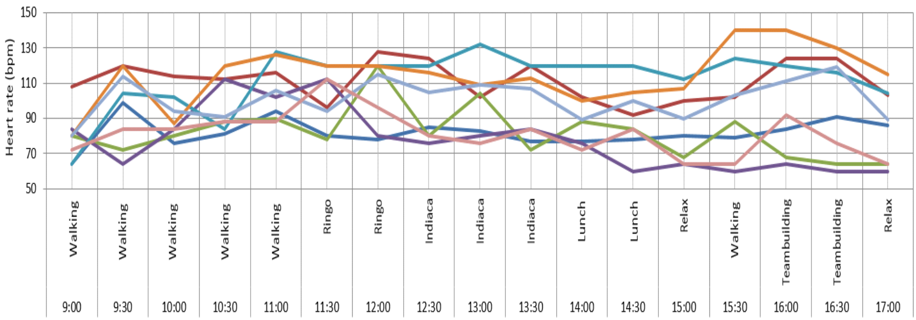


Figure 1. Course of the load of individual participants during Day 1 of the programme

The load during the late morning games reached in most participants values above the all-day average heart rate, overall 102 bpm. In the afternoon, a teambuilding activity was held with a higher rate of short fast run in the interval concept of load – the average value was 99 bpm.

Figure 1 presents the concept of the introductory day with fluctuating load; the realization of sports games brought an active involvement of the subjects and a more significant load for their bodies. In connection with this, also a bigger energy intake was required by the participants' bodies to cover the energy needed in activities. The average value of physical load ranged 78-115 bpm for the whole group, the all-day average was 95 bpm.

Day 2:

Physical activities with a higher level of cognitive components were intended – a strong adrenalin experience and speed-endurance activity with significant fluctuations in heart rate values. Morning activity used the basal form of orienteering (running in the field and working with a map). Most participants reached higher values of heart rate; the average value of heart rate of the group was 115 bpm, exceeding the day's average. During the visit to the rope park, the heart rate of the participants increased; however, the expected dramatic increase based on the realization of the adrenaline force activities did not occur. A significant increase in load could be observed in all participants during running together (2 km) with increased intensity (approx. 5:20 minutes/km). In the afternoon, accompanying testing was performed with the UNIFITTEST battery (sit-ups/1 min). Compared to the standard of the Czech population (Kovář & Měkota, 1995) with respect to the age limit, the results ranked rather slightly below the average (with the exception of the participant G with an excellent result). For the conclusion, a team activity was held requiring planning and solving an outlined problem; then a short final walk.

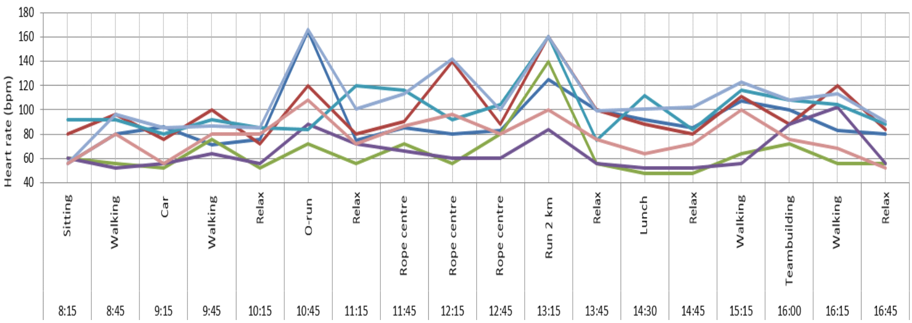


Figure 2. Course of the load of individual participants during Day 2 of the programme

The average value of the physical load ranged 65 to 107 bpm for the whole participants' group during Day 2, the all-day average was 86 bpm, but with significant fluctuations in values.

Day 3:

Long-term endurance load of low to moderate intensity - 40km bike ride mostly in a flat landscape profile with short activities (geocaching) and a team-building game. During the day, two UNIFITTEST battery tests were performed: the Cooper 12minute run on the athletic oval – the performance of most participants ranged well below the average border. The performance in 12minute run (except for the participant G) correlates with the Ruffier test index and reflects the not-too-positive state of the fitness of the subjects. In the afternoon, standing long jump (two attempts) was performed, in which participants reached below-the-average to significantly poor results, which could have been affected by the overall fatigue from previous days and the actual fatigue of the legs after the long bike ride (with the exception of the participant G with a slightly above the average performance).

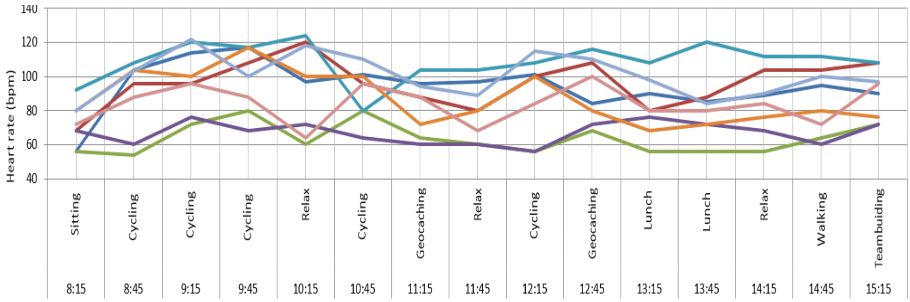
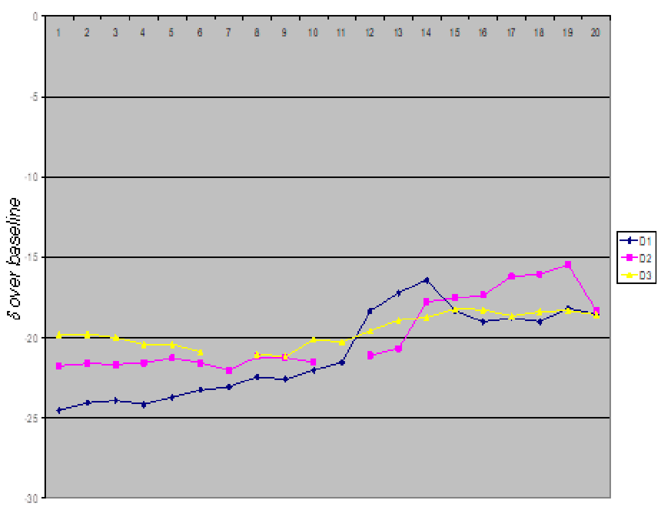


Figure 3. Course of the load of individual participants during Day 3 of the programme

The average physical load value for the whole group of subjects ranged 64 to 109 bpm during Day 3; the group's all-day average was 88 bpm.

The key area of monitoring was the verification of the effect of physical activities and varied physical load on the lag-time of pellets with controlled release of glucose. It is clear from the Figure 4 that there was no destructive effect of the load on the process of glucose release from the pellets during the all-day load on individual days. To the contrary, the expected increase of sugar level in the organism is apparent on the curves of the graph corresponding to in vitro specified lag-time of 240 minutes.



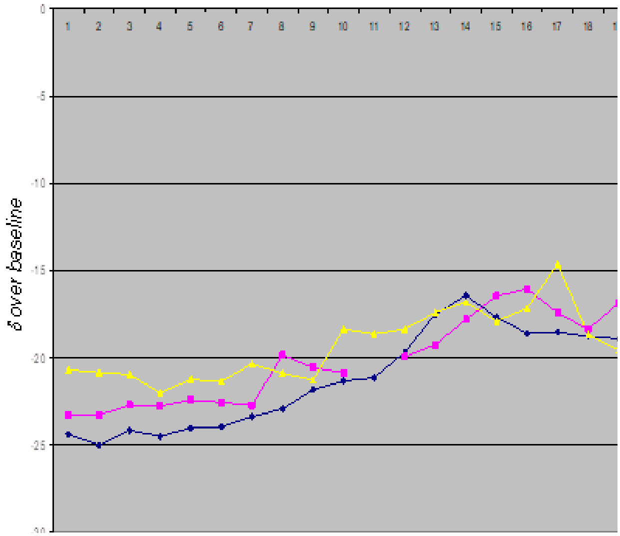


Figure 4. Examples of the pattern of energy release from the pellets in selected subjects

Notice: C1, 2, 3 / D1, 2, 3 – individual days of the programme/subjects (C, D); x axis – numerical series 1 to 20 indicates 30 to 60 minute intervals between breath tests; y axis – δ over baseline; isotope ratios of breath samples were measured relatively to universal standard, Vienna Pee dee Belemnite (VPDB, and were evaluated in the delta notations, δ, according to the equation: $\delta = 1000\,(R_{sample} - R_{standard})/R_{standard}$, where: Rsample is the abundance ratio of the minor, heavier isotope of the carbon to the major, lighter carbon isotope, i.e. $^{13}C/^{12}C$. Rstandard is the abundance carbon ratios of reference CO_2 gas.

The results have shown that the character and severity of physical activity do not influence the preset lag-time of the designed pellets and have validated the expected independent release of glucose from special ‘functional food’.

Discussion

The physical activity programme suited to the research objectives of the project. The controlled physical motion programme enabled to verify the stability of lag-time of pellets with controlled release of glucose under varied conditions and motion load during all-day physical activity in the group of adolescents and young adults with T1D.

The field realization of the pre-seed project with a progressively increasing and changed load during day-long sports activities enabled to obtain the following results to verify the lag-time (240 min) of pellets using breath tests with ^{13}C-glucose performed on adolescents and young adults with T1D:

- In most samples, a higher ^{13}C increase is expected at time point 9 to 10, i.e. after 4.5 to 5.0 hours after ingestion (lag time and metabolic time).
- On the second day of testing, a double dose of the tested dietary supplement (glucose pellets) was administered, therefore the change is more pronounced.
- The flat curve on the third day corresponds to the higher ^{13}C background because of ^{13}C deposition in the bodies from previous days and character of sport activity, the steady intensity aerobic motion of low to medium intensity. This day also displayed most hypoglycemia occurrence which can be attributed to the nature of continuous aerobic load with the highest demand on the processing of glucose.

Physical activities and breath tests helped to verify lag-time stability in demanding conditions of active life. It remains to solve the food manufactory of the pellets in such a way so that the foods with 'smart sugars' were tasty (palatable) and in sufficient quantity in special supplements.

It was found in our part of the project that the lag-time of constructed pellets is independent on glycemia and physical activity, but dependent on the correct ingestion of 'functional food', This, together with the necessary amount, is the biggest challenge for the common use of the pellets in real life, and is open to further development.

Conclusion

The expected outcome of the project was the confirmation of lag-time glucose in various physical activities of adolescents and young adults with T1D. Within the realized field phase, it was experimentally demonstrated that varied physical load does not affect the absorption of sugar from glucose pellets administered in semi-liquid and liquid food. An important challenge and an area of further research still remain: an optimal form of the pellets in order to ensure appropriate amount of sugar to prevent hypoglycemia during physical activities.

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Conflict of interest: The authors declare that they have no conflict of interest.

Author contributions: I. R. and K. R. created programme of specific field motion activities.

D. N. proposed topic, designed research and ^{13}C-breath test technology. All authors wrote the manuscript, D. N. reviewed and I. R. finally edited the manuscript.

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GYMNASTICS AND DANCE

PARAMETERS OF POSTURAL SWAY AFTER SPECIFIC EXERCISES AND GYMNASTICS PERFORMANCE

Böhmerová Ľubica, Hamar Dušan, Luptáková Jana, Rupčík Ľuboš
Faculty of Physical Education and Sports, Comenius University in Bratislava, Slovakia

Abstract

The aim of the study was to analyze the relationship between the parameters of postural sway and gymnastics performance in all-around competition and on selected individual apparatuses (balance beam and uneven bars). Twenty female gymnasts (mean age 15.3 ± 3.8 years, mean height 156.2 ± 8.7 cm and mean weight 46.2 ± 7.6 kg) competing at national level underwent stabilographic tests in standard upright stand, special heel rise stand (releve), one leg stand, handstand as well as in standard stand immediately after specific gymnastic elements namely 5x flick-flack on floor, 5x giant swings on highbar, 10x long axis twists in upside down position on rings. The results showed that gymnastic performance was more closely correlated to stabilographic parameters obtained immediately after gymnastics elements (10x long axis twists in upside down position on rings, $r = 0.827, p \leq 0.001$) or further specific positions (heel rise stand - releve, $r = 0.825$, $p \leq 0.001$; one leg stand, $r = 0.810$, $p \leq 0.001$; hand stand $r = 0.762$, $p \leq 0.01$) than those measured under general conditions without preceding exercise ($r = 0.634$, $p \leq 0.05$). While correlating results on individual apparatuses the highest correlations were found between balance beam performance and mean velocity of center of pressure (COP) in the heel raise test ($r = 0.866$, $p \leq 0.001$), as well as between uneven bars performance and mean velocity of COP in handstand test($r = 0.802, p \leq 0.001$). Results of present study indicate that parameters of postural sway measured immediately after specific gymnastics elements or in specific static gymnastic positions can be used to monitor the efficiency of gymnastic training. In addition they can also provide useful hints for the further specialization of gymnasts.

Key words: *postural sway, artistic gymnastics, sport performance*

Introduction

Functional evaluation is becoming an integral part of preparation of elite athletes. Application of the results gained into training process can increase its efficiency and contribute to sport success. This trend is obvious also in artistic gymnastic. However, current scientific knowledge on the application of data from diagnostic tests into practice is rather limited. Main reason for this unfavorable situation is relatively low number of elite gymnasts, which can be subjects of scientific studies. This is in contrast with rather popularity of gymnastics among young children. However, most of those entering classes of artistic gymnastic at the young age do it as a general sport and not pursue a carrier in this demanding sport.

Artistic gymnastic represents a typical coordination-esthetic sport with rather complicated structure of factorsaffectingperformance. This is partially because of complex character of this sport, in which excellence has to be presented in different disciplines (6 in men´s and 4 in women´s categories). Every of theseput different demands on motor capabilities, skills as well as on psyche. In addition, especially in women period of peak performance falls into relatively early age, between 16and 19 years.

Elite performancein artistic gymnastic, similarly to other similar sports, requires integration of multiple factors, whereas absence of any of them may impose a substantiallynegative impact on the final product, i.e. sport performance.

Several authors as for example Jemny et al. (2011), Arkaev and Suchilin (2004) have agreed on the most important performance affecting factors. Somatotype, explosive power, flexibility and balance are of decisive importance for gymnastics disciplines

Our paper deals with role of balance, namely with the relationship of balance capabilities (maintaining horizontal position of the center of gravity) on various gymnastic apparatuses.

Static balance plays is of importance namely while performing elements at zero velocityusing small area of support either on the ground or on particular apparatus. This capability also affects kinesthetic perception of dominant positions while practicing various difficult gymnastic elements (Böhmerová et al., 2005). Dynamic balance play a role while performing element of pulling and swinging character, namely those requiring in addition multiple rotation around horizontal and longitudinal transverse and fast stabilization of the body after landing at the end of element.

The aim of our study was to find the relationship of parameters of balance obtained in quite stance with or without preceding gymnastic elements with combined performance as well as performance on particular apparatuses.

Subjects and methods

Group tested consisted of twenty female artistic gymnasts (mean age: 15.3 ± 3.8 years, mean height: 156.2 ± 8.7 cm and mean weight 46.2 ± 7.6 kg) competing, according to Code of Points of FIG, at national level. Their all-around and also individual apparatuses ranking was based on the results achieved in latest 3 competitions preceding testing.Balance parameters have been registered using a computer based stabilographic system FITRO Sway check, Fitronic Slovakia. The system monitors the horizontal COP movement based on the analysis of the distribution of vertical forces registered by means of 4 tensometric force sensors in corners of stabilographic platform. The position of the COP wascalculated and registered at a frequency 100 Hz (Hamar, 1997). As the parameter of postural sway the mean velocity of COP was calculated from stabilographic curve.

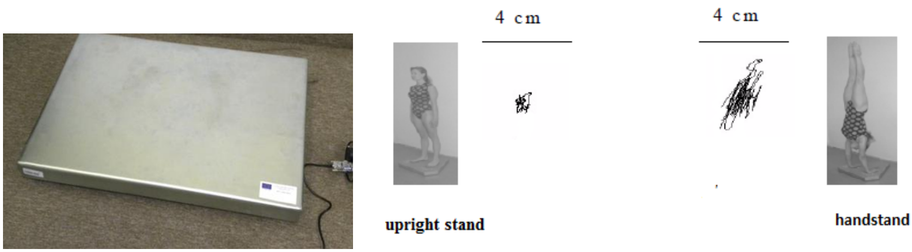

Figure 1. Stabilographic platform and COP movement during upright stance and handstand

The subjects underwent two 30-second tests of postural swayunder standard conditions, i.e. in bipedal quiet leg stand as well as in one leg stand, heel rise stand and handstand. Test in bipedal quiet stand after preceding sets of gymnastic elements (five flic-flaks on the floor, five giants circles on high bar, ten long axis twists in upside down position on rings) were separated by 5 minutes periods. These tests lasted 2 minutes each.Criterion for evaluation was mean value of two attempts (Zemková, Hamar, 1998).

Spearman correlation analyse was employed to asses relationship between gymnastic performance and stabilographic parameters. Statistical significance between particular correlation coefficient was assed according to Howell (2011).

Results

The closest correlation with all-around gymnastic performance was found for mean velocity of center of pressure in standing position immediately after performing ten long axis twists in upside down position on rings($r = 0.827$), in heal rise stand (releve) ($r = 0.825$),one leg stand ($r = 0.810$), allstatistically significant at 0,1% level and handstand ($r = 0.762$)significant at 1% level. Correlation coefficient between non-specific quiet stand test and all-aroundperformance was lower ($r = 0.634$, $p \leq 0.05$) than for above mentioned tests.

Performance on beam showed the closestcorrelation with the results of balance test in heel rise stand ($r = 0.866$, $p \leq 0.001$), followed by one leg stand ($r = 0.797$) and bipedal stand after head down hang with 10 rotation around vertical axis ($r = 0.768$) statistically significantat 1%level.

Correlation coefficient between beam performance and balance parameter measured duringhandstand was $r = 0.711$statistically significant as well at 1%level, whereas coefficient reflecting its relationship with balance parameters obtained in quiet stand were lower ($r = 0.664$) at 5% level of statistical significance.

Performance on uneven bars correlated most closelywith mean velocity of center of pressure measured during handstand ($r = 0.802$, $p \leq 0.001$). Correlation to the same parameter obtained during standard leg stand was ($r = 0.664$) at 5% level of statistical significance. Such close relationships of stabilographic parameters obtained during handstand with performance on uneven bars indicates that parameters of static balance obtained in such a specific position enables more precise assessment of predispositions for excellent familiarization of gymnastic element on this apparatus. Our findings are in agreement with various authors, showing that gymnastic performance is limited by quality of maintaining balance (Arkaev-Suchilin, 2004; Assemanet al., 2004, 2005, 2007; Bringoux et al., 2000; Damionet al., 2001, 2004; Gajdoš, 1980; Gaverdovskij a kol., 1979; Hatiar, 1989; Kuchen et al., 1981; Mikuláš, 1983; Perečinská, 1994; Rovná, 1969, 1981, 1982; Vuillerme a kol. 2004).

Correlation analyses revealed that gymnastic performance, both in multidiscipline as well as on specific apparatuses was more closely correlated to the parameters of balance (mean velocity of center of pressure) obtained in specific gymnast position or in quiet stand immediately after performing specific sets of gymnastic elements. Therefore these parameters can be considered better predictors of gymnastics performance.

Considering results of balance tests performed in specific gymnastic positions as in static position immediately after completing set of specific gymnastic elements may significantly facilitate decision process of future specialization. For example, considering performance potential on beam it seems more appropriate to evaluate parameters of balance in quiet heel rise stand (releve) or one leg stand than parameters obtained during bipedal quiet stand.Closer correlation of balance parameters under such conditions is obviously due to specific adaptation to long term drills of various elements on the beam.

The best predictor of uneven bars performance has proven to be balance test in handstand. Also suitable is test in quiet stand performed immediately after tenlong axis twists in upside down position on rings.

Conclusion

It can be concluded that gymnastic performance is significantly correlated to parameter of balance, namely mean velocity of center of pressure measured in quiet stand as well as in quiet stand immediately after selected set of gymnastic elements. These tests carried out immediately after the set of gymnastic elements correlated with gymnastic performance more closely than results of test without preceding specific exercise. Therefore these tests can be considered as more appropriate tool for functional assessment of special gymnastic preparedness as well as for the process of talent identification and recommendation for further specialization.

It can be assumed that application of assessment of balance capabilities creates favorable conditions for the enhancement of training efficiency and improvement of gymnastic performance.

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CROSS-SECTIONAL PLANTOGRAPHIC STUDY IN MEN AND WOMEN ARTISTIC GYMNASTS

Hedbávný Petr, Kalichová Miriam, Svobodová Jana
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

*Purpose***:** Artistic gymnastics is a sport which positively affects human locomotion system on one hand, on the other hand at a professional level the early specialisation has negative effects. A long-lasting specialised gymnastic training may result in permanent changes in the structure of musculoskeletal system. Due to specific load, mainly landings, the changes are expected in lower extremities and feet. The aim of this work was to examine the condition of longitudinal plantar arch in artistic gymnasts and find differences in the condition between men and women as well as among different age categories.

*Methods***:** The group consisted of 84 probands, 52 girls and 32 boys aged 6 - 25 years, all at higher performance levels. After documenting the basic anthropometric data, we examined the condition of longitudinal plantar arch using sensor platform Emed and the acquired data were processed using Novel software. The acquired plantogram data were evaluated using Chippaux-Šmiřák method. To evaluate the observed relations we used non-parametric tests, Mann-Whitney U test and Spearman Correlation, at 5 % level of significance.

*Results***:** In most of the tested persons one of the stages of high arch was diagnosed, concretely in 87.5%. We found out no statistically significant difference in condition of foot arch between men and women of matched age groups. When comparing longitudinal foot arch among different age categories, a tendency of foot arch to lower with increasing age was observed.

*Conclusion***:** We assume that higher longitudinal foot arch in gymnasts may be one of the causes of frequent injuries of ankle and foot. We recommend to add more compensatory exercises focusing on plantar flexors stretching into the training process.

Key words: *foot arch, Chippaux-Šmiřák, gymnastics, plantogram*

Introduction

Artistic gymnastics is a sport with manifestation of early specialisation and competitors perform at elite levels at the edge of adulthood. Due to high intensity load not only during competitions but also during trainings, injuries are very frequent

(Chilvers, Donahue, Nassar & Manoli, 2007). Permanent changes in the structure of musculoskeletal changes result from the long-time gymnastic training.

Despite high level of prevention in form of more and more perfect landing platforms, injuries occur mainly during landing (Mills, Pain & Yeadon, 2006; Vormittag, Calonje & Briner, 2009; Pérez-Soriano et al., 2010). Most landings are performed from the height of 2–4 m (McNitt-Gray, 1991). A gymnast is penalised for landings with bigger flexion in knee and hip joints. Therefore, an effort to perform landing according to the rules into a slight knee-bend increases the load acting on the gymnast´s lower extremities which increases the risk of injury and permanent changes which may lead also to changes to plantar arch (Slater, Campbell, Smith a Straker 2015). McNitt-Gray (1991) and Mills, Pain and Yeadon (2009) agree and state that during landing reaction forces are 10 x higher than gymnast´s weight. Possible musculoskeletal changes may result from the character of gymnastic movements.

As stated, plantar arch height changes with age even without extreme load. Forriol and Pascual (1990) state a value of Arch index 1 at the age of 1 (range 0.7–1.35), which gradually decreases to values 0.6 (range 0.3–0.9) and then increases to 0.8 (range 0.3–1.1) approximately between ages 12–14. It is certain that apart from these ontogenetic changes, the plantar arch quality is affected by function of selected foot muscles and in case of their insufficient activity this may lead to negative effects on plantar arch. Gymnastics is coordination-aesthetic sport and for its correct performance flexed feet, during which plantar muscles are activated, are a necessity. A condition for a correct take-off is performed plantar flexion due to concentric activity of involved muscles. Eccentric contraction of plantar flexors participates in stable landing.

Aydog et al. (2005) in their study investigated relation between muscle strength of ankle joint and structure of feet of gymnasts aged 18–30. The results show that both indexes were lower in gymnasts compared to control group, which proves higher plantar arch. In comparison with other sportsmen, e.g. Handball players, footballers, weight lifters and wrestlers, plantar arch index in gymnasts was lower, i.e. Plantar arch was higher (Aydog, Tetik, Demirel & Doral, 2005). The results also show a significant correlation between the values of these indexes for left and right foot in both gymnasts and control group.

The aim of our work was to find out the condition of plantar arch in professional men and women gymnasts of different age categories. With regard to different character of specific sport load we expect differences in plantar arch condition between men and women. We also expect that longitudinal plantar arch height will be different among different age groups.

Methods

Research group characteristics

The selected group consisted of 52 female artistic gymnasts aged 8 to 25 years and 32 male artistic gymnasts aged 6 to 25 years. All of them intensively train artistic gymnastics. The gymnasts were divided into three age groups according to categories of a competition programme of Czech gymnastic federation. The first age group consisted of probands aged 6 - 10 years, the second of probands aged 11 - 14 and the third aged 15 and older (see Table 1).

Table 1. Characteristic of research group

	GM1	GM2	GM3	GW1	GW2	GW3
(N)	14	7	11	19	18	15
age	7.5 ± 1.5	13 ± 0.9	18,1 ± 3	10.7 ±1.2	14.3 ± 0.8	19.4 ± 3.3
h [m]	1.25 ± 0.08	1.52 ± 0.08	1,71 ± 0.06	1,4 ± 0.09	1,6 ± 0.07	1,6 ± 0.04
m [kg]	24.81 ± 3.96	42.46 ± 6.0	66.03 ± 9.6	29.4 ± 4.96	44.2 ± 6.49	56.0 ± 5.87

Methods of data acquisition

Height and weight of each probands were measured using height gauge and digital weighing scale. An electronic device Emed was used to measure longitudinal plantar arch condition. It is a pedographic sensor platform which scans pressure of a sole on the platform using calibrated sensors and gives information on size of reaction forces and the area of contact between sole and platform. The platform acquires data using calibrated capacity sensors. Both feet were measured for a period of 20 seconds in order to get plantograms. Data were recorded using a software Novel.

Data processing methods

Novel database essential programme was used for data post-processing.For accuracy of acquired data we used only the middle part of the recording of length of 10 seconds during which the tested person stabilised the position. The plantograms for left and right foot were exported from these recordings. The picture of the contact area of sole with platform was evaluated using Chippaux-Šmiřák method which except for pes planus distinguishes three stages of high arch.

Methods of data evaluation

Measured and processed data were evaluated using mathematical-statistical methods in programme Statistica 12. The results divided into 9-stage scale according to Chippaux-Šmiřák norms were statistically evaluated (see Table 2).Regarding the fact that data do not have normal distribution non-parametric Mann-Whitney U test and Spearman correlation coefficient calculation were used for evaluation of observed data.

Tab. 2. Scale of foot index values according Chippaux-Šmiřák

Scale	**Values**	**Specifications (Ch.-Š.)**
1	60.1 - 100 [%]	VF - very flat foot
2	50.1 - 60.0 [%]	MF - middle flat foot
3	45.1 - 50.0 [%]	SF - slightly flat foot
4	40.1 - 45.0 [%]	N3 - normal foot N3
5	25.1 - 40.0 [%]	N2 - normal foot N2
6	0.1 - 25.0 [%]	N1 - normal foot N1
7	0.1 - 1.5 [cm]	SH - slightly high foot
8	1.6 - 3.0 [cm]	MH - middle high foot
9	> 3.1 [cm]	VH - very high foot

Results

Within the research we measured feet of 52 female and 32 male artistic gymnasts, altogether we acquired 186 plantograms. In most cases, i.e. in 87.5 % one of the stages of high foot arch was diagnosed. The results for individual groups are listed in Table 3. Whereas the unit of index for high foot arch is the cm and for normal and flat foot is the % according to norms by Chippaux-Šmiřák, the percentages are in bold italics in the Table 3.

Table 3. Foot arch indexes according to norms by Chippaux-Šmiřák, i [cm] – index for high foot arch, i [%] – index for normal and flat foot arch, numbers in the italics are data for the normal and flat feet, GW – group of women, GM – group of men

i [cm]/*i [%]*

GW1		**GW2**		**GW3**		**GM1**		**GM2**		**GM3**	
L	**P**	**L**	**P**	**L**	**P**	**L**	**P**	**L**	**P**	**L**	**P**
3.8	4	3.4	2.9	***30.8***	1.8	10.5	11.2	10.3	9.1	11.2	2.5
2.8	3.6	5.6	5.1	4.5	3.7	4.5	5.3	9.75	2.6	11.4	11.5
5.4	2.6	4.2	4.6	5.5	5.2	10	9.4	2.9	2.7	10.2	4.6
4.2	4.2	2.2	1.8	1.6	5.1	7.75	6.6	8.9	8.6	***21.54***	***30.3***
4.7	4.6	2.5	***1.28***	4.3	4.6	8	1.64	11.3	10.8	1.75	8.8
		5.3	4.7	5.1	4	9.7	10.6	10.2	9.8	8.5	12.9
		4.7	5.1	1.6	***5.46***	10.2	9.8	10.8	12.2	***34.75***	***36.29***
		5.8	5.2	5.6	5.7	10.8	12.2			11.3	2.5
		3.6	5.5	5	5.9	11.2	2.5			8.2	9
		6.2	6.2	2	1.8	11.4	11.5			***17.72***	***8.82***
		6	5.8	4.5	3	7.3	7.9			12.3	13
		5.5	5.7	3.1	3.6	8.8	8.4				
		3.3	4.3	4.9	4.8	9.4	7.9				
		5.6	4.9	***13.8***	***25.8***	10.5	10.2				
		5.7	5.3	***1.82***	***3.45***						
		5.2	5.3	2.6	***27.9***						
		1.6	2.4	1.2	1.5						
		6.2	4.5	***37.5***	***14.8***						
		5.4	5.1	***13.1***	***25.4***						
		5.6	6.1	3.6	***14***						
		4.9	4.2	4.8	4.8						
		3.7	3	3.7	4.9						
		6	1	***18.6***	***29.4***						
				4.8	4						

Table 4. The number of cases in individual grades of the scale for determining the height of the foot arch according to Chippaux-Šmiřák. GW – group of women, GM – group of men, N1 - normal foot N1, N2 – normal foot N2, SH - slightly high foot, MH - middle high foot, VH - very high foot arch.

GROUP	N2	N1	SH	MH	VH
GW1	0	0	0	2	8
GW2	0	1	1	7	37
GW3	5	9	2	7	25
GM1	0	0	0	2	26
GM2	0	0	0	3	11
GM3	3	3	0	3	13
Total N	8	13	3	24	120
Total %	4,8	7,7	1,8	14,3	71,4

Due to the impossibility of comparing the values in different units (cm and %), we converted the results to a 9-point grading scale. The number of cases for individual grades in individual groups of athletes both in absolute terms and in percentages are entered into the Table 4.

Discussion

The aim of the work was to examine condition of plantar arch in female and male artistic gymnasts. With respect to differences in load on locomotion system between the sexes we expected differences in plantar arch height. Non-parametric Mann–Whitney U test was used to find out the differences in plantar arch height between female and male gymnasts. There was no statistically significant difference found on a level $p = 0.05$ between the groups (group1: $p = 0.491$, group2: $p = 0.9582$, group3: $p = 0.425$). Thus, plantar arch height expressed by a stage on the scale does not change in relation to sex in none of the observed groups. This result is in concordance with a study by Staheli (1987) who found only negligible 2 % difference in plantar arch height between the sexes.

We also expected that plantar arch height in artistic gymnasts increases with age. Non-parametric Spearman correlation calculation at the level of statistical significance 0.05 was used to evaluate this relation. Correlation coefficient ($r_{sp} = -0.33$) appeared to be statistically significant, however, its value represents only low dependency.

Negative value of the coefficient points out the indirect proportion between the variables. The result therefore describes the tendency of decreasing foot arch with increasing age.

Aydog, Tetik, Demirel and Doral (2005) in their study in which they compared longitudinal foot arch of 25 elite gymnasts with 30 non-sportsmen and other 61 elite sportsmen, football players, wrestlers, weight lifters and handball players, found out that plantar arch in gymnasts is significantly higher compared to all the control groups. The authors of the study state that plantar arch is lowest in childhood and highest in age of 12 - 14, then arch slowly decreases and becomes stable at the age 20 - 30 when its condition is normal until approximately age of 60.In our research group we found incidence of higher foot arch in most probands (87.5%) and a relation between foot arch height and age with tendency of foot arch to decrease with increasing age. These facts correspond to results of a study by Aydog as the average age of our group was only 10.49 years and plantar arch gradually decreases up to the age of 25 in the oldest tested person.

Plantar flexors influence plantar arch height and if weakened, plantar arch is lower. Dylevský (2003, p. 178) states that in these muscles active participation was proved, using electromyography, only during load, which does not occur during normal standing or walking. Based on these facts we can assume that frequently performed plantar flexion in gymnasts mainly during landing (Soriano, 2007), when load is sufficient for foot plantar flexion activation, has influence on high foot arch formation in gymnasts. However, this explanation is contradicted by results of a study by Aydog, Özçakar et al. (2005). They diagnosed the strength of plantar and dorsal foot flexors in elite gymnasts and normal population. They found out that strength of foot dorsal flexors in gymnasts is two times lower than in control group of non-sportsmen, while the strength of plantar flexors was the same. Authors think that the results are not accidental and are caused by either insufficient training of dorsal flexors or adaptation on specific sport load.

We also assume that condition of plantar arch may have influence on injuries which in gymnasts are more frequent in ankle joint and nearby structures. Giladi, Milgrom and Stein (1985) performed a study in 295 army recruits and found out a statistically significant difference between stress injuries and plantar arch height. Overload injuries was by 29.6 % higher in high foot arch feet than in normal feet. However, the influence of foot arch height on injury in gymnasts cannot be proved or disproved. In our opinion it is important that this relation is clarified so that it would be possible to prevent injuries of ankle joint in gymnasts by specific exercises.

In summary it is unclear what caused the high incidence of high plantar arch in the observed group of gymnasts and other studies should be performed to find it out.

The results showed an unexpectedly high percentage of high foot arch among the observed gymnasts. From this reason it is advisable to use also other methods of acquiring and evaluating plantograms in order to verify the accuracy of our data. It would be beneficial to perform longitudinal study including a control group during which changes of plantar arch height could be better analysed with regard to age and specific training load.

With regard to the findings we recommend to include more compensatory exercises for plantar flexors stretching mainly in children and adolescence age. These exercises could positively influence condition of plantar arch together with possible prevention of foot injury.

Conclusion

In conclusion, we diagnosed high longitudinal foot arch in most of both men and women artistic gymnasts we measured. As results showed sex plays no role in plantar arch height. With increasing age plantar arch height tends to lower, which is a positive change in gymnasts. Since this was a cross-sectional plantographic study, we cannot clearly determine how significantly artistic gymnastics influenced the height of the foot arch and its observed changes. However, we believe that gymnasts should include compensatory exercises into their training process which would minimise the effects of specific load on feet so that possible ankle joint injuries, so frequent mainly in female gymnasts, are prevented.

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THE LEVEL OF SELECTED GYMNASTIC ABILITIES IN ELEMENTARY SCHOOL PUPILS

Hedbávný Petr, Svobodová Lenka, Kalichová Miriam
Faculty of Sports Studies, Masaryk University, Brno

Abstract

Purpose: Gymnastics positively influences the condition of locomotion system, increases muscular as well as functional fitness and cultivates movement performance. According to the Framework Educational Programme Ministry of Education, Youth and Artistic gymnastics should form one of the basic parts of physical education content on elementary and secondary schools. The aim of the work was to evaluate the level of selected gymnastics abilities in pupils of selected elementary schools in the Czech Republic.

Methods: The group consisted of 351 pupils of 8th Year of elementary school in the Czech Republic, 198 boys and 153 girls. Basic gymnastic movement elements were selected: forward roll, backward roll, handstand, cartwheel, pullover, squat vault and straddle vault. The level of performance was evaluated by observation. The quality of performance was evaluated by 4 – level scale. Interviews with individual teachers were held in order to acquire information on number of lessons per week, content of lessons and material equipment of gymnasiums.

Results: We found out that more boys than girls train gymnastic during the compulsory lessons of physical education. Girls, however, try more different types of gymnastic exercises. When comparing exercises on different equipments, both boys and girls performed best at forward roll and straddle vault. Boys performed worse in handstand and cartwheel, girls performed worse in handstand and squat vault. We also found out that at some schools not all the selected elements were trained and practised.

Conclusions: A positive fact is artistic gymnastic is trained in boys at all selected schools, in girls at 13 out of 14 schools. Almost all teachers had a positive relationship with gymnastics, however, lessons spent training gymnastics at some school was not sufficient for mastering of the selected elements. Another factor affecting the level of performance of gymnastic elements was poor equipment of gymnasiums and low functional awareness in mainly girls, as stated by teachers.

***Key words**: artistic gymnastics, evaluation, scale, education*

Introduction

There are three directions, where the research aims in the topic of school physical education (shortly PE) – first being the preparation of future teachers, second the content of gymnastics based classes and their quality and last but not least the application of gymnastics. Gymnastics positively affects the condition of a human locomotion system, enhances muscular and functional fitness and cultivates the movement exhibition of the learner. According to Framework Educational Programme Ministry of Education (shortly RVP, a document stating the aims and expected skills and knowledge a pupil should acquire on certain schools – elementary, high, …), gymnastics should be one of the elementary parts of PE at elementary and high schools. University lecturers are aware of the importance of incorporating gymnastics in PE, which may sometimes be only physical activity that children have (Sloan, 2007). More and more extensive research is focused on the methodology of exercises in gymnastics for certain age groups or groups with different level of fitness (Кравчук, Санжарова & Голенкова, 2016). This is also linked with usage of new apparatus in class to make gymnastics is school more fun and diverse (Dobrescu & Dănilă, 2013). As was mentioned before, a lot of researches are focused on content of gymnastics classes in PE. Another aim of researchers is aimed on the effect of gymnastics skills on certain movement skills. For example a research focused on effects of gymnastics on quickness of young boys and girls on elementary school is aimed this way (Aleksić & Aleksić, 2014).

Even though contemporary researches proves, that gymnastics physical preparation is linked to a success in various sport branches, artistic gymnastics is sadly getting less popular overtime – from the perspective of pupils and teachers – and is often substituted by different, less demanding (on resources, organisation and methodology) physical activities (Valach & Halasová, 2013). According to the theory of sensitive periods and motoric learning, it is necessary to include gymnastics already on elementary school, because the use of sensitive period for development of specific motoric abilities is crucial for the process of learning. Furthermore, the consequences of not using the sensitive period is felt in teaching gymnastics exercises on high school. As the child become older, it is harder and harder for him or her to begin with gymnastics exercises.

According to RVP MŠMT, gymnastics should be one of the elementary parts of PE on elementary and high schools. Each school creates School Education Program (shortly ŠVP, created from RVP), where teacher creates a content of education himself in a manner, where pupils are able to fulfil the expectations stated in RVP. This process often leads to deterioration in difficulty of gymnastic exercises, mostly because of general deterioration of motoric level and activity of whole population. According to Máček and Radvanský (2011), the level of motoric activity – mostly of Czech, middle childhood children – decreased about one third in one generation.

Bago (2010) was already trying to find out the level of motoric skills in artistic gymnastics among children on elementary schools. The research was aimed at testing and it pointed out the quality of education in PE classes for girls in 8th grade on six different elementary schools. For receiving particular information for further processing, the testing method was used. There were seven-level scales created for every skill in a sense of grades (highest quality – lowest grade). The outcome of this study had shown that a level of motoric skills in artistic gymnastics on aforementioned elementary schools ranges from average to below average.

We decided to continue in ongoing testing of gymnastic skills and executed an extended research with a use of customised scale. The goal of our research was to find out a level of certain gymnastic skills among pupils on chosen elementary schools in Czech Republic.

Methods

The research comprised of 153 girls and 198 boys from 8th grade and from 14 different elementary schools. The amount of time dedicated to education of gymnastics on chosen schools ranged from 8 to 10 hours per year. Girls from school two were left out of evaluation, because they do not have gymnastics in their PE classes at all. A method of research was observation of gymnastic exercises incorporated in ŠVP on all monitored schools – forward roll, backward roll, handstand, cartwheel, pullover on bars, straddle and squat vault over buck horse 100 cm high. Every pupil performed every exercise three times and only the best try was incorporated in evaluation. Evaluation of chosen exercises was executed by four-level scale, because the seven-level scale (Darwish, 1987) was too complicated for our analysis. Level 1: excellent execution – with no mistake; Level 2: average execution – with a minor mistake; Level 3: poor execution – with a help of a teacher; Level 4: was not able to execute. This testing was supplemented by structured interview with open questions with the teacher, which helped us to get the needed information about the amount of time dedicated to gymnastics and material and personal aspect of education.

Acquired figures were statistically processed. First we calculated modus separately for boys, girls and every exercise. Also, we converted the results of the scale into points, where the level of exercise execution equals to amount of points acquired. Furthermore, we implemented a variable called „score/student“, which states the average value of acquired points per student and „score/student/element“, which stands for the average amount of points per student for one exercise. With a help of these variables, we were able to compare boys, girls, exercises and schools with each other. With regard to the fact that data are not in a normal distribution, we used a nonparametric Analysis of

Variance test for finding out the statistical significance – the Kruskal-Wallis test with multiple comparison of mean rank.

To obtain additional information about the conditions of teaching gymnastics at the individual schools, we conducted an anonymous structured interview with 21 teachers of physical education of the tested classes. In order to discuss the causes of the results of motor testing, we asked questions about number of lessons per week, content of lessons and material equipment of gymnasiums, personal relationship to gymnastics and its teaching, functional preparation of pupils for gymnastic exercises or pupils' access to artistic gymnastics. During the interview, an audio record of the respondents' answers was taken, which was subsequently processed in written form.

Results

We can approach the results from different angles. First is judging the level of acquiring of each exercise, boys and girls separately, by aforementioned scale. Table 1 shows how many individuals executed the exercises on level one, two, three and four, separately for boys and girls. It is noticeable from the data that the most frequent level in 5 monitored exercises was 1. We can see that in forward roll (N = 128), straddle vault (N = 127) and squat vault (N = 114), most of the boys acquired high score (total amount of boys = 198). Boys acquired the biggest amount of level 4 evaluation with a cartwheel. On the other hand, the data acquired from girls are quite different. When it comes to girls and cartwheel, the most acquired level was level1 (N = 76) and it was not different with forward roll (N = 107) and straddle vault (N = 73) (total amount of girls 153).

Table 1. Gymnastic abilities level. Amount of students (boys/girls), who performed exercises on level 1 - 4, highlighted values are the most frequent levels for each exercise

	BOYS (N)				GIRLS (N)			
element	level 1	level 2	level 3	level 4	level 1	level 2	level 3	level 4
forw roll	128	57	7	6	107	38	5	3
back roll	96	69	14	19	65	67	7	14
cartwheel	30	55	13	100	76	36	8	33
handstand	35	37	67	59	18	9	39	87
pull over	75	15	50	58	29	21	47	56
squat vault	114	41	19	24	38	21	7	87
straddle vault	127	51	7	13	73	45	12	23

According to the fact that the total amount of evaluated boys and girls was different, we calculated average value of execution of boys and girls separately. Low number equals better execution of an exercise on average. These average points per student are listed in Table 2. Boys were better on average at five exercises (squat vault, handstand, pull over, straddle over, and backward roll), when the girls were better at two of them (cartwheel and forward roll). The smallest difference in average point acquisition between boys and girls was in backward roll (0.03 points), biggest in squat vault (1.17 points). All of the values are listed in Table 2. We aligned each exercise by aforementioned readings of the average level of execution. Forward roll ended up on a first place for both girls and boys, further order is different.

Table 2. Elements order by quality of execution. On the left – Average value of points acquired by execution of individual exercise by boys and girls, highlited values shows the reader, who was better at execution of a certain exercise – if it were boys, or girls. B – G expresses the subtraction of the value between boys and girls; On the right – order of monitored gymnastic exercises by average value of level of execution – separately for boys and girls (identical exercise are highlighted with the same colour)

element	**BOYS score/ student**	**GIRLS score/ student**	**B - G**
squat vault	1.76	2.93	1.17
cartwheel	2.92	1.99	0.94
handstand	2.76	3.27	0.52
pull over	2.46	2.85	0.39
straddle vault	1.53	1.90	0.38
forw roll	1.45	1.37	0.08
back roll	1.78	1.80	0.03

rank	**BOYS**	**GIRLS**
1	forw roll	forw roll
2	stradle vault	back roll
3	squat vault	stradle vault
4	back roll	cartwheel
5	pull over	pull over
6	handstand	squat vault
7	cartwheel	handstand

The results were not judged only by individual exercises, because we were also interested in quality of education of artistic gymnastics on individual schools. We calculated the amount of points per boy per exercise and also per girl per exercise, on all of the fourteen schools and listed the results in Table 3.

Table 3. Level of gymnastics on schools. The difference in execution between boys and girls on individual schools, blue – boys were better than girls on this school, pink – girls were better than boys, green – boys and girls were roughly on a same level

school	1	2	3	4	5	6	7	8	9	10	11	12	13	14	avg	SD
BOYS score/ student/ element	1.73	2.64	2	1.97	2.29	1.75	2.13	2.14	1.59	2.23	2.1	2.14	2.53	2.62	2.13	0.32
GIRLS score/ student/ element	2.33		2.54	2.94	2.68	2.64	2.13	2.11	1.78	1.73	1.82	2.14	2.56	2.59	2.31	0.39

Discussion

Our study had shown the level of gymnastic skills on 14 monitored schools, where the time donated to artistic gymnastics is about 8 – 10 hours per school year. The results were judged from multiple different angles and compared with facts we found out in a structured interview with teachers. Firstly, we have evaluated the level of individual gymnastic exercises acquisition of boys and girls separately. The assumptions that students will do best at forward roll were confirmed. The most frequent identical evaluation of boys and girls was proved in two exercises – forward roll and straddle vault, where both of the exercises were executed without a mistake (level 1). To create an option for comparing, we converted the successful execution into percentage (The higher the value, the worse the execution). Total level of gymnastic exercise acquisition on monitored schools ranged between 42% and 65%, according to our percentage calculation. This result is in unison with sooner published works, where Bago (2010) states that the percentage ranges between 42.5% - 62.5% and Valach and Halasová (2013) from 47% to 60%.

The data for comparison are known to us for straddle vault, where the level of acquisition corresponds with Bago's (2010) 39% and Valach and Halasova's (2013) 41% - the value of 38%, which were find out based on our observation, is then in accordance with already published results. We can think of forward roll and straddle vault as exercises, which are for the students probably the least difficult. Based on the fact that the students are able to execute these exercises on a fairly high level (modus – level 1), they might be incorporated in other PE classes, which are not focused only on artistic gymnastics, as a supplement for development of coordination abilities.

With handstand, we can observe a high amount of unsuccessful tries by both boys and girls. Also the percentage of the level of execution – 75% - is in accordance. This percentage, which is quite high, points to a lack of physical fitness for this exercise, especially when to comes to girls. Even though the exercise can be performed with help, teachers were afraid to execute it because of a risk of an injury. As the interviews shows, more than a half of interviewed teachers did not know the grounding exercises or easier version of this exercise.

The difference between boys and girls in the quality of execution of individual exercises was subjected to statistical analysis. We can say, based on the achieved level of relevancy in Kruskal-Wallis test ($p=0.000$), that we proved a statistically significant difference between quality of execution of certain gymnastic exercises. This considers boys and girls separately. It was proved by consequential comparison of average standings for all groups (Kruskal-Wallis test) that there is a statistically significant difference in level of acquisition of certain skills between boys and girls in cartwheel and squat vault (Kruskal-Wallis test: H (13, N= 2457) =602.3386 p =0.000; B cartwheel – G cartwheel: 0.000, B squat vault – G squat vault: 0.000).

When it comes to cartwheel, girls achieved the percentage of 49%, whereas boys achieved 73%. We suppose that the superior coordination skills, which came to light, are connected with flexibility. Bago (2010) states the value of 56% in this exercise, which as a bit better than overall successfulness of execution of boys and girls in our research, which is 61%. When comes to squat vault, the results are upside down. Girls achieved lower level than boys in ratio of 73% to 43%, average of students was then calculated to 58%. It was 48% in Bago's (2010) case. The results of interviews points more to the psychic barriers of girls, but those can be eliminated by well picked grounding exercises and by good help, in which some of the teachers were not quite sure.

The smallest difference between boys and girls was statistically proved in back roll with percentage difference of 0.75%. For comparison of the overall level of this exercise is there Bago's (2010) 50% and Valach and Halasova's (2013) 55%, which is not so different from our 45%. It is good to notice that with almost the same average level of execution (score/student boys – 1.78 and score/student girls – 1.8), this exercise moved to a second place, right behind the forward roll. When it comes to boys, a back roll is situated on a fourth place. In comparison of acquired score, what is above average in girls score perspective is not even an average score in the perspective of boys.

Let's summarize the standings of individual exercises by successfulness of execution separately for boys and girls. Boys – forward roll, straddle vault, squat vault, back roll, pullover, handstand, cartwheel. Girls – forward and back roll, straddle vault, cartwheel, pullover, squat vault, and handstand. Each of the monitored exercises has some biomechanical foundation and is conditioned by increased requirements on the level of certain motoric abilities, be it strength, coordination or flexibility. These standings points to the conclusion that it is easier for girls to accomplish exercises with higher requirements to coordination, and boys are also ok with strength based exercises. Aforementioned standings can point us in a direction when it comes to creation of ŠVP, which is often created (for artistic gymnastics) identically for boys and girls and because of this, the interest of students deteriorates quickly. By better aim, when it comes to basic didactical rules, the motivation of students would improve.

Then we got to comparison of results between boys and girls on individual schools. We found out that in 7 out of 14 monitored schools boys were better, girls bested boys in 2 of them and there were minor differences in 5 of them. The results were verified by nonparametric Kruskal-Wallis test, which proved, that there is statistically significant difference between the levels of execution between chosen gymnastics exercise. The consequential multiple comparison of p values showed us that out of overall number of 91 relations, 14 of them showed this statistically significant difference, when it comes to artistic gymnastics of boys. We came to the same result with the comparison of observed gymnastic exercises executed by girls, where the fact was proved by multiple comparison at 13 out of 78 monitored relations. Another point that was shown by multiple comparison was that the statistically significant difference between boys and girls was proved on only 3 schools, namely school 1, 4 and 6 (Kruskal-Wallis test: H (26. N= 2513) =176.92 p =0,000; BS1 – GS1: 0.035, BS4 – GS4: 0.003, BS6 – GS6: 0.033). Let's point out the fact that it is the same at school 2, where girls do not have artistic gymnastics incorporated in PE classes at all. By detailed judgement of results on 1, 4 and 6, it comes to light that the cause of the differences are slightly above-average performances of boys and highly below-average performances of girls. We conclude, that the cause of the difference is not in insufficient material background of the school, but the core is in the pedagogical process.

Conclusion

The aim of our work was to evaluate the level of gymnastic exercises performed in 8^{th} grade on elementary school. We can state that based on the data we collected, the level of acquired skills on monitored schools is on average comparable with the results of other authors (Bago 2010; Valach & Halasová, 2013). Boys managed to achieve better results than girls. Cause of this might be the age of the monitored sample, where boys tend to perform strength and coordination based activities – exactly what gymnastic exercises can offer.

The content of artistic gymnastics creates a basic exercise for development of particularly coordination abilities and these are getting harder and harder for students in contemporary grasp of PE. The level of these abilities depends on many factors. Firstly on the teacher's character. As the results of the interviews showed, teachers today lack in usage of grounding exercises and apparatus. They are not using the appropriate methodical and organisation forms and are not often able to offer help necessary for the artistic gymnastics education, which leads to rise in risk of injury, demotivation of students and the school's management in performing gymnastic exercises at all.

There are many suggestions on improving current state of affairs, but we would like to primarily point out two of them. Firstly, it would be beneficial to focus on the proper education of teachers during their university studies, but also later in their pedagogical practice through training courses. Secondly, we recommend the development of gymnastic skills in younger age which is primarily within the competence of the Ministry of Education that creates the RVP.

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PHYSIOLOGICAL ASPECTS OF MUSCULOSKELETAL SYSTEM IN CLASSICAL DANCE

Moc Kralova Dagmar, Podzimkova Michaela, Kapounkova Katerina, Rezaninova Jana
Department of Health Promotion, Faculty of Sport Studies, Masaryk University Brno, Czech Republic

Abstract

Introduction: Classical dance at a professional level is comparable to top sport. Physiotherapist applies basic elements of musculoskeletal system physiology to training. It leads to more economical movement. A balance must be struck between the aesthetic and the health aspects. *Methods:* In the case study was evaluated the quality of the technical skills of ballet female proband L.Z. (female sex, 23 years old, height: 165 cm, weight: 46 kg, right upper extremity and left lower extremity are dominant). The physiological aspects of the musculoskeletal system according to Capova were monitored. In this article we will focus on examinations in selected basic positions of classical dance, which was part of the incoming and outgoing examinations. There were 8 therapies at a frequency of 1–2 times per week between the examinations. Therapies were focused on the perception of body details according to different concepts and their application to the classical dance trainings. *Results:* The proband after therapies gives a feeling of greater certainty in individual positions. Objectively in the first position there is no longer a hyperpronation of feet, nor excessive external rotation of the hips and anteversion of the pelvis. In a grand plié, the proband is capable of correction for achieving a greater degree of physiology. In positions of grand battement jeté the proband is able to partially center the hip joint of the training leg. The extension at the lower range of motion is done with no problem. Higher range of motion leads to significant development in one segment of the spine and the syndrome of open scissors. The conscious work on adjusting the technique of individual classical dancing positions has led to the improvement of the subjective feelings of the proband (the feeling of certainty and stability). *Conclusions:* It is necessary to respect the long duration of the changes in order not to forcibly remove the compensatory mechanisms of the proband. The limit of this study is a number of the probands. and only subjective evaluation of the muscle performance.

Key words: *dance anatomy, dance kinesiology, muscle chains, injury prevention, posture stabilization, dance, ballet, imagination*

Introduction

Classical dance at a professional level is undoubtedly a very demanding physical activity. Training volume, intensity and coordination performance is comparable with top sports. Due to the position of dancing outside the sporting environment, it is necessary to realize different possibilities and level of dancer awareness. Of course, they should have at least a basic awareness of prevention of musculoskeletal system injuries and its position in professional life.

Strict rules of ballet schools form incorrect movement stereotypes in its dancers. Dance educators often do not realize the fact that the prescribed positions are carried out by their tutoring with respect to strict rules. There is no chance for subjective perception of the balletic positions. Balance between the aesthetic and the health aspect can be set individually for each dancer.

The main goal of this case study is to inform dance educators and dancers about physiological aspects of musculoskeletal system according to Čápová (2008). These aspects come from developmental kinesiology, postural ontogenesis, kinesiology and anatomy and serve to diagnostics and therapy too. The physiological aspects include information about seven main areas of human body and their knowledge can improve an individual approach to dance training. This can contribute to long-term professionalism and minimization of musculoskeletal disorders.

There is no complex of movement stereotypes that repeats itself at a certain interval in dance. That is why the dysbalances of the musculoskeletal system of professional dancers can not generally be determined. Most of the movements are not only in one plane, but there are movements in diagonal directions performed by muscle coactivation. The muscles are connected to functional units through bones, ligaments and fascias. The function of the muscles is integrated into muscle chains. Many chains are involved in a particular movement at the same time. However, the activity of the entire chain is not a condition (Véle, 2006; Struhár, Dovrtělová, & Kapounková, 2014).

The description of muscle chains is not uniform. They differ according to the author. The problem of myofascial chains can be approximated as an interconnection of the muscles of different localizations through fascial lines. It is possible to understand the context of the musculoskeletal imbalance in seemingly distant areas with the way of fascia (Myers, 2009).

Čápová (2008) describes these muscle chains as a part of postural ontogenesis and calls them *"physiological aspects of musculoskeletal system"*. These aspects include position of foot, an ankle, a knee and a hip joint, area of pelvis, intersegmental play of vertebras, position of scapula, shoulder and elbow joint, wrist and hand. For the needs of classical dance, we will start with the description of the elements of the musculoskeletal physiology in the area of the hip joints.

The hip joints should move in slight external rotation. However, this movement depends on the anatomical and other dispositions of the dancers. The easiest version of the external rotation applied to the dance technique is in the second position. In this position the dancer adjusts the degree of external rotation in which the pelvis is in the neutral position and the hip joints centered without the need for compensation. If the dancer's hip joint external rotation is limited by anatomical barriers, we do not increase the range of motion. This could be at the expense of the quality of the movement stereotype (Franklin, 2004; Simmel, 2014).

When successfully correcting the movement stereotype into the external rotation of the hip joints, the compensation mechanisms can be expected to disappear. In the caudal direction we can see stable knee joints without the tendency to uncontrolled hyperextension (Čápová, 2008). The flexible and stable foot arch allows the transfer of information from the training surface through the stable ankle joints to the trunk.

In the case of danseuse, the functional instability of the ankle is explained with insufficiency of the periarticular muscles, tendons and joint ligaments. According to the Freeman method, there can be use a balance aid. The Propriofoot concept is also used to prevent leg and ankle joints' instability. Both methods appeal to the previous handling of the foot support on the fixed support (Pavlů, 2003; Palaščáková Špringrová, 2010).

Cranially from the hip joints center position, the pelvis should be in neutral position. This is followed by the intersegmental play of the individual vertebrae. It leads to the straightening of the entire spine to the area of the head.

When moving the spine to extension, the intervertebral discs can be protected against overturning by intraabdominal pressure. It is the activity of the deep spinal stabilizers with relation to the surrounding muscles during this movement (Clippinger, 2007).

Richardson, Hodges, & Hides (2004) point out the significant connection between the ribs, vertebrae, sacrum and muscles (transversus abdominis, obliquus internus abdominis, spinal erectors, multifidi, quadratus lumborum, latissimus dorsi et gluteus maximus) through the thoracolumbar fascia . This theory is based on the assumption that the fascia remains tensioned when the spine is stretched by the pressure of the muscles. The movement is similar as a "pulling". Thus, the mechanical demands on the lumbar spine are not so high. The combination of these two theories provides an optimal stereotype of the retroflexion of the spine.

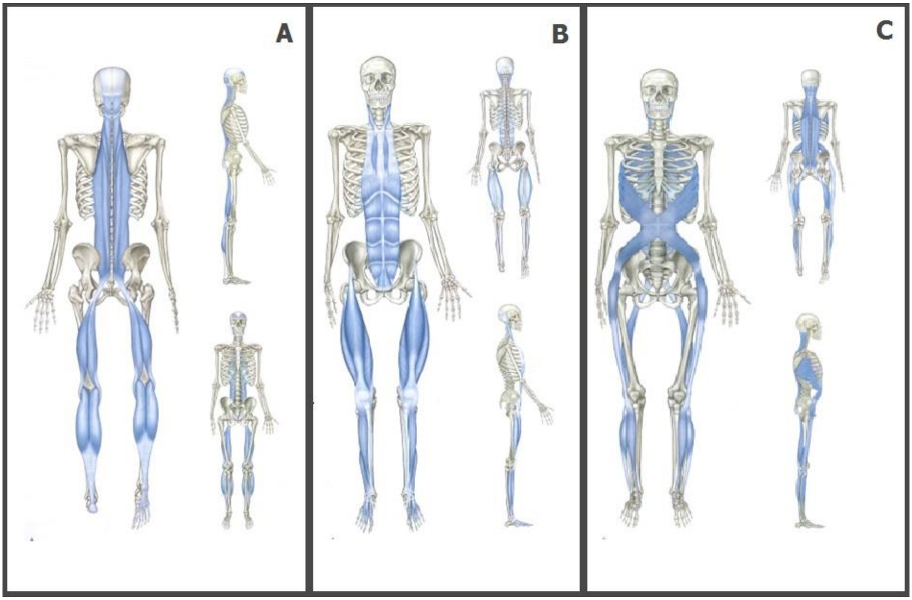

Figure 1 A. The Superficial Back Line, B The Superficial Front Line, C The Spiral Line (Myers, 2009)

Optimal spinal extension also affects muscle chain function. The optimal stereotype of the spine retroflexion is caused by balance between the superficial back and front lines (Fig. 1 A, B) (Myers, 2009). In dancing, it is also important to work on standing on one leg. There is an important function of the spiral line (Fig. 1 C) connecting the rhombic muscles and the serratus anterior muscle. This ensures the centered position of the scapula.

Most of the time in classical dance the upper limbs are working in open kinematic chains with the arm in internal rotation. It is necessary to concentrate on the centered position of the scapulas. Optimal stimulation to the centered position should also be carried across the trunk by the muscle coactivation. It can lead to the stabilization of other motion segments (Čápová, 2008; Kolář, 2009).

All these settings are very rough. Effective change requires an individual sensitive approach that allows a dancer to feel the detail of his or her own body. When economical movement is automatized, the individual starts using it in common situations. This is essentially about the use of neuroplasticity of the central nervous system in practice (Feldenkrais, 1990). The quality of the movement corresponds with the quality of solution and the ability to imitate movement. The kinesthetic experience of movement is much more important than the theoretical description of the right technique (Kolář, 2016; Králová, Novotný, & Řezaninová, 2013).

Methods

The case study included a complex kinesiological analysis, an analysis of individual ballet positions according to Čápová and further examinations. In this article we will focus on examinations in selected basic positions of classical dance, which was part of the incoming and outgoing examinations. The test was completed by an intra-abdominal pressure test. It serves as a control test between therapies.

Subjects

In the case study, the quality of the technical skills of ballet female proband L.Z. (female sex, 23 years old, height: 165 cm, weight: 46 kg, right upper extremity and left lower extremity are dominant) was evaluated. The physiological aspects of the main seven areas according to Capova (2008) were monitored. The participant came to our laboratory because of the examination. There were 8 therapies at a frequency of 1-2 times per week between the incoming and outgoing examination. Therapies were focused on the perception of body details according to Capova´s concept and application these details to the classical dance trainings.

Diagnostic of physiological aspects according to Capova in individual classical dance positions

We chose the First position as a basic position which is trained in classical dance. The Grand plié and the Relevé elements were chosen because of feeling of ankle instability. The Grand battement jeté position and Backward bend of the spine were chosen for control of the subjective discomfort of lumbar spine area.

The proband in **the First position** (Fig. 2) compensates an insufficient external hip rotation. There is the pelvis anteversion and expressive lumbar lordosis. This position is not optimal for the activity of the deep stabilizers. This can be supported by the presumption of insufficient diaphragm function. We can see the compensation in the area of the ankle joints, which are in the hyperpronation during the first position.

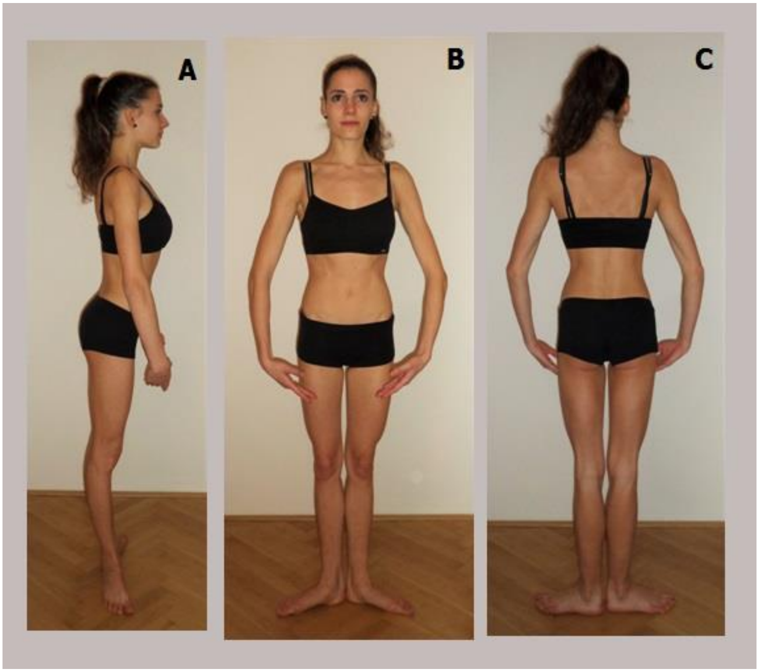

Figure 2. First position A side view B front view C back view

When performing the **Grand plié** element in the first position (Fig. 3), the most marked deviation from the optimal position is the tilting of the trunk and pelvis. It results in the femur internal rotation and the position of the knee medially from the axis. There is an obvious emphasis on the foot load above the big toe. The foot is again in a hyperpronation. Even the distribution of load between the lower limbs is not symmetrical. The left lower limb is loaded more. Proband feels that the right leg is subjectively weaker and less stable.

Relevé on balls of feet *(demi-pointes)* in the First position shows an asymmetry in the area of MTP joints. This may be due to a different mobility of these joints between the limbs. However, this asymmetry is also visible in the Relevé on tips of toes *(sur les pointes)*, it is possible to conclude that the load of lower limbs is different. We can see insufficient support of the toes and MTP joints in the position Relevé on balls of feet *(demi-pointes)*. The foot is in inversion. The reason is a compensation of an insufficient range of motion into the external hip rotation. This is again a compensatory mechanism supported by a proprioceptive disorder of the foot.

Figure 3. Grand plié position A side view B front view C back view

Grand battement jeté (Fig. 4) can be done in three directions. This examination is focused only on the side direction (*de coté*). We can see compensative lateroflexion of the trunk, which is necessary in the lower limb elevation above 90 °. However, there should be an effort to minimize it. The fact that the lateroflexion of the trunk is bigger in elevation of the left lower limb must be taken into account when correcting this position.

Backward bend of the spine was done with one upper limb in the Third ballet position of the arms (180° flexion) and rotation of the head towards this upper limb. Second upper limb is in the First position of the arm. Feet are in the First position as well. We can see the excessive trunk rotation to the upper limb in the First position. The excessive range of motion to the spine extension leads to hypermobility of one segment of the spine. Correction of this movement will be accomplished by activating the deep stabilizers and percepting the optimal position of the individual segments. The position of the arms is necessary to be evaluated in the context of the whole upper limb and the position of the trunk. For example, the risk of "split scissor" syndrome in the trunk can be reduced by lower position of the upper limb.

Figure 4. Grand battement jeté position front view

Therapy

The goal of therapy is to improve a perception in corrected dance positions. The result should be the ability to distinguish tiny nuances between the physiological and non-physiological settings of the individual motion segments.

First, it should be a matter of drawing new settings for each of the motion segments in the basic positions. The dancer should apply these mechanisms within the training after the corrected posture in static positions. Furthermore, the goal is to automatically use these mechanisms in all static and dynamic elements of classical dance.

The first therapy included the work with the diaphragma, breathing and intraabdominal pressure activation. It was used training both of supine and prone positions of third month from postural ontogenesis. The second one continued with intraabdominal pressure training. It was connected in standing position with training foot support when standing on the whole foot. These two physiological aspects (intraabdominal pressure and foot stabilization) were used in more difficult position as a squat or lunge forward. This is related to the centered position of all motion segments.

The third therapy started with control the intraabdominal pressure, breathing and foot stabilization in squat. These aspects were applied in the First position. The goal of this therapy was to set the level of hip joint external rotation without pelvis anteversion and its perception. The First position was made harder with Propriofoot utility under the forefoot and heel. The main goal of the fourth therapy was to control the foot support in the previous positions with end in Relevé demi pointe and en pointe.

The fifth therapy was focused on resume of previous therapies. It was completed with training of the Grand battement jeté and perception of the hip joints position as a physiological aspect. The level of lower extremity elevation was evaluated. Further therapy inculded the work with the whole spine and both upper extremities during backward bend of the spine. The proband tried to perceive the scapulas and thoracic spine when changed the position of upper extremities. Then the work with intraabdominal pressure and intervertebral 3D motion was used to backward bend of the whole spine.

Results

In **the First position**, the excessive external hip rotation and the pelvis anteversion are no longer visible. The insufficient diaphragm function is not compensated in the area of the ankle joints, which are not in the hyperpronation during the first position.

In **the Grand plié**, the proband is able to correct the unequal load of the lower limbs and the trunk lateroflexion. A slight improvement is visible in medial knees deviation. The pelvis is in neutral position. Also, the proband minimized the lumbar kyphosis with a lower range of motion during the hip, knee and ankle flexion.

There is no apparent asymmetric foot load, nor its eversion in **Relevé position**. The reason can be better support function of the diaphragma and coactivation of deep stabilizers with connections to lower extremity. On the other hand small oscilations of the ankle joints and slight medial deviation of the patellas are still present.

The proband is able to partially center the hip joint of the training leg in the position of **Grand battement jeté**. The compensative lateroflexion of the trunk is necessary in the lower limb elevation above 110°.

On one hand the **backward bend of the spine** at a lower range of motion is done without any problem. On the other hand, there is a tendency for significant development in one segment of the spine during large range of motion. The intra-abdominal pressure test was performed. Light pathologies persist at the *spina iliaca anterior superior* on the right and next to the central portion of the rectus abdominis on the left.

However, improvement can be observed objectively and within the subjective feelings of the proband. The proband miss the automatization process. It is maybe done with short length of the therapeutical programme.

Discussion

In ballet, as well as in gymnastics, it is not possible to prevent the large range of motion during positions at the edge of physiology. This negative effect can at least be minimized. It is always a compromise between the requirements of the dancer, the coach or the teacher and the physiotherapist's view. We always try to achieve positions as close as possible to physiological settings, but with regard to preserving the character of movement.

Franklin (2004) considers an absolute relaxation of the stretched muscles as a prerequisite for a quality and safe stretching. This claim is at odds with Clippinger's (2007) requirement to at least partially maintain a physiological position. These two statements can only apply if the individual has a high level of flexibility. If these two parameters can not be reached at the same time, the position as close as possible to the physiological setting would be the right choice.

Even in terms of safety of stretching for the needs of classical dance, the optimal selection of talented children would be based on congenital dispositions. Selected children should have the optimal range of motion into external hip rotation, a flexible spine that develops in all segments, and last but not least, overall flexibility. Cortical functions can also affect overloading or injuries. An example of this is ideomotorics as a means of the economic performance perception (Kolář, 2009). Another reason for including the cortical functions evaluation into the criteria would be the better movement imitation and reduction of the risk mental frustration.

As described in his Feldenkrais methodology (1990), a long-term non-optimal movement stereotype can be transformed through a large number of repetitions of simple movements with an emphasis on their experience. As a part of therapy, this methodology seems to be beneficial. The proband changed the stereotype of squat with emphasis on the centered position of the knee joints. Through the perception training, an economical setting in ballet positions has also been achieved.

With longer intervention, we can expect automatic use of this setting in classical dance technique. We should take into account the quality of the cortical functions, which according to Kolář (2009) is directly proportional to the speed of motor learning. The ability of the proband to learn quickly about new movements is undoubtedly the result of the good quality of congenital cortical functions, but also their continuous and long-term development of dance.

Classical dance schools place great emphasis on the strictness of the technical design, such as the description of the basic posture in the ballet by Pásková & Ždichyncová (1973) with a specific description of the angular adjustment of the body segments to each other. From a health point of view, for example, the degree of external hip rotation of each dancer should be adjusted individually. The angles are only rude at this time. The dancer's feelings are the most important.

Classical dance, at some points, matches with physiotherapy. According to Pásková & Ždichyncová (1973), the lower limbs should be rotated from hip joints to feet. Audy (2013) describes a three-point foot support. The proband would be able to observe almost all the rules of classical dance techniques, except for a strict angular adjustment to the external rotation of the lower limbs. The physiological adjustment of individual motion segments in the strict technique of classical dance is thus possible provided the anatomical disposition of a particular dancer.

In the case of proband, the non-optimal foot support and tendency to distorsion can also be observed when standing on toes (Fig. 3). After correction and control of the support in this position on the floor, the Propriofoot concept was used in therapy to stabilize the front part of the foot and the ankle in position on the toes (Palaščáková Špringrová, 2012). The proband responded well to this therapy.

Conclusions

Classical dance combines elements of aesthetics, art and top sport. Similarity to top sport is due to the high demands on performance often beyond the physiology of the musculoskeletal system.

In practice, we have been able to incorporate elements of physiotherapy focused on the perception of our body into the dancer's training program. In particular, it is the perception of the position of individual motion segments. Often, this position is regulated by precise angular settings. This can serve as a guide. Equally important is to perceive the response to these instructions through the subjective feelings of the dancers and the reactions of the musculoskeletal system.

The limit of this study is a number of the probands. That is why we would like to continue with this work at public dance conservatories. Other limit is only subjective evaluation of the muscle performance. Our goal is to search any quantitative method.

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THE EFFECT OF DANCE INTERVENTIONS ON THE LEVEL OF CHOSEN PHYSICAL ABILITIES IN ELDERLY PEOPLE. REVIEW

Skotáková Alena[1], Vaculíková Pavlína[1], Sklenaříková Jana[1], Grmela Roman[2]
[1]Department of Gymnastics and Combatives, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic
[2]Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Physical activity has undoubtedly a lot of physical and mental health outcomes. Dance has the big potential to be an attractive physical activity. Also it can be adjusted to meet the needs of the elderly. The aim of this article is systematically reviewed the scientific literature to identify the effects of different dancing intervention programs on the level of movement abilities like balance, endurance and leg strength in the elderly.

We examined the Web of science database focusing on different dance interventions in elderly people. For this article, the final selection of 25 articles published between 2000 and 2017 was used. All of the studies met the inclusion and exclusion criteria. We analyzed the type of intervention, study design, demographics of participants, and results.

This review includes studies concerning dance programs performed around the world. Many different dance styles were used as intervention programs - creative dance, social dance, ballroom dance, salsa, country dance and also using a dance pad. In nine articles, the authors confirmed the positive effect of dance intervention on the level of balance, including three studies using dance pads. In three studies, dance was confirmed as more suitable for their targeted group than other physical activities. Conclusions of three articles show the positive influence of the dance on the level of endurance ability, two articles confirmed the positive effect of dance programs on the level of leg strength.

Previous studies have dealt with issues related to the quality of life in the elderly in the association with the growing number of the elderly in the society. This process leads to the need and thus a need further investigation arises. Findings indicate the dance interventions have the positive effect on the level of chosen physical abilities which are also very important limiting factors influencing the quality of lives of elderly. The results demonstrate that dance provides not only physical but also many psychological benefits, and should be promoted as one of the most appropriate form of leisure activities for the elderly.

***Key words**: Dance, elderly, balance, endurance, leg strength*

Introduction

One of the key issues in the 21st century is maintaining the quality of life of the aging population. Aging is associated with a progressive decline of mental and physical abilities. Considering the current demographic changes in many civilizations there is an urgent need for measures permitting an independent lifestyle into old age. The critical role of physical exercise in mediating and maintaining physical and mental fitness is well-acknowledged. It is well known that physical activity programs are one of the tools that can be used to prevent noncommunicable diseases and can help to sustain active life in the elderly.

Dance could also be a type of physical activity that may appeal even to people who are not otherwise active and may be a form of activity that is more acceptable than others. It is suitable for all fitness levels and ages (Svobodova, 2017).

The findings of many studies (Sherrington et al., 2011) suggest that dance interventions for the elderly are effective both as prevention of falls and as an instrument to maintain or improve cognitive functions (Verghese et al., 2003). It is estimated that by 2030 the number of patients suffering with dementia will have risen by 70 % (Raboch, 2010).

Dance as a means of improving cardiorespiratory parameters is effective, nevertheless there are studies which confirm that it is just as effective as any other type of exercise (Dewhurst, Peacock, & Bampouras, 2015) (Rodrigues-Krause, Farinha, Krause & Reischak-Oliveira, 2016).

The aim of this article is systematically reviewed the scientific literature to identify the effects of different dancing intervention programs on the level of movement abilities like balance abilities, endurance and leg strength in elderly people.

Methods

We examined the Web of science database focusing on different dance interventions in elderly people. For this review, the final selection of 25 articles published between 2000 – 2017 has been used. It has met the inclusion and exclusion criteria and analyzed the type of intervention, study design, demographics of participants, and results. The searching was https://www.facebook.com/acrogoddess/videos/10155284128178401/ conducted from June to September 2017.

Keywords included *dance* AND *balance abilities* AND *elderly*, *dance* AND *balance abilities* AND *old age*, *dance* AND *postural stability* AND *old age* OR *elderly, dance* AND *endurance* AND *old age* OR *elderly, dance* AND *leg strength* AND *old age* OR *elderly.*

The inclusion and exclusion criteria are outlined in Table 1.

Table 1. Criteria for Study Inclusion or Exclusion

Inclusion	**Exclusion**
English language	Non-English language
Follow up movement abilities	Follow up social and psychological influence
Age of participants up to 60	Age of participants under 60
Actual research	Reviews
Published between 2000 – 2017	Published before 2000

Results

Table 2. Summary of Studies Included in the Current Review – Balance abilities

"dance AND balance abilities AND elderly", WOS, 2000 - 2017							
	Title	Authors	Intervention	Dance type	Participants	Methods	Results
1.	Dancing or Fitness Sport? The Effects of Two Training Programs on Hippocampal Plasticity and Balance Abilities in Healthy Seniors	Rehfeld, K. at al. (2017)	18-month dancing intervention and traditional health fitness training. 6 months, twice a week for both groups for 90 minutes. For next 12 months once a week for 90 min in both groups.	Dance classes induced a permanent learning situation with constantly changing choreographies, which participants had to memorize accurately	14 members of dance group (7 male, 7 female, 67+ years) and 12 members of fitness program (5 female, 7 male, 68+ years)	Postural control - Sensory Organization Test (SOT) implements in Balance Master System (Neurocom International).	Only the dancers achieved a significant increase in the balance composite score. Hence, dancing constitutes a promising candidate in counteracting the age-related decline in physical and mental abilities.
2.	Creative Dance Improves Physical Fitness and Life Satisfaction in Older Women	Cruz-Ferreira, A. et al. (2015)	24 weeks series of 50 min	Creative dance	57 woman (65-80 years) - experimental and control group	Senior Fitness Test - 30-s chair stand test, 6-min walk test, chair sit-and-reach, 8-ft up-and-go test, BMI	Creative dance has a positive effect in different dimensions of functioning and has the potential to contribute to healthy aging. This could be related to the integrated mobilization of physical, cognitive, and social skills promoted by creative dance.
3.	Dance combined with magnetic pulse stimulates the ability of walk and balance in elder people	Lu, T et al. (2015)	Control group training twice a day, morning and night about 35 minutes. 6 months in total. The observation group: the same dancing program, conduct magnetic pulse stimulation for auxiliary treatment after training every time.	Waving dance	96 participants (75-80 age, 25 male, 71 female), random divided to 2 group	Walking ability test, Balance ability test	Waving dance could obviously improve elderly people's walk and balance ability, and the improvement effect could be ever more significant when combined treatment with magnetic pulse stimulation. Such effect is obviously better than the effect improved only by waving dance.
4.	Postural Stability of Older Female Scottish Country Dancers in Comparison With Physically Active Controls	Dewhurst, S. et al. (2015)	Scottish country dancers were compared with physically active controls	Scottish country dance	20 dancers vs 33 physically active controls	Force platform	Scottish country dancers participation resulted in similar postural sway as participation in other physical activities, however nondancers may need a greater amount of regulatory activity to maintain balance.

5.	**Group fitness activities for the elderly: an innovative approach to reduce falls and injuries**	Bianco et al.(2014)	Experim.group- two times per week for a total of 70 min per session. Participants were invited to dance continuously for two balls (e.g.,Valzer and Mazurka) and afterward they were invited to sit and rest for the following three balls (e.g., Valzer, Valzer and Polka).	Ballroom dance (valzer, mazurka, polka)	122 participants. Exper. Group -75 subjects ((73 - 78 age, 26 - 30 BMI), control group 47 subjects (74 - 79 age, 27 - 31 BMI)	Berg Balance Scale (BBS), Barthel Index (BI), anamnesis of falls	The BBS seems to be a valid and reliable tool able to be adopted also by professionals of the ballroom dancing sector (e.g., Valzer, Polka and Mazurka classes). Instructors may evaluate the functional ability of their attendees through BBS to easily obtain more information and better plan ballroom dance classes.
6.	**Effect of Tai-chi exercise on lower limb muscle strength, bone mineral density and balance function of elderly women**	Song et al. (2014)	All women in the three groups do the above said exercises for 40 minutes and the exercise intensity is controlled to be medium.	Senile dance	105 participants - 3 groups (tai-chi, senile dance, walking group) 61 - 68 age	Bone density, Lower limb muscle strength, Lower limb skeletal muscle content, Movement dynamic balance test system produced by USA	Compared with the senile dance and walking exercises, the short-term Tai-chi exercise effect is not obvious, however, once the exercise period is extended, that is, continuous exercise for 8 months or even above 12 months, the advantage of Tai Chi is more and more significant. The study suggests that as a fitness measure, Tai Chi is more suitable for long-term exercise and its short-term effect is not obvious.
7.	**Scottish Country Dance: Benefits to Functional Ability in Older Women**	Dewhurst , S. et al. (2014)	The dancers had a minimum of 10 years participatory involvement in Scottish country dancing. Participants were engaging in some form of physical activity at least three times a week.	Scottish country dance	EG - Scottish country dancers 26 (67 - 72 years, CG - physically active nondancers 34 (71 - 77 years)	6 min Walk test, 6 m walk time, 8 ft Up-and-go time, , Chair Sit-and-Reach, Static balance Assessment - force platform	Regular physical activity can maintain body composition and postural stability with advancing age; however, Scottish country dance can delay the effects of aging on locomotion-related functional abilities.
8.	**A cognitive-motor intervention using a dance video game to enhance foot placement accuracy and gait under dual task conditions in older adults: a randomized controlled trial**	Pichierri, G. et al. (2012)	Twelve-week cognitive-motor exercise program twice weekly that comprised progressive strength and balance training supplemented with additional dance video gaming. CG - only strength and balance exercise during this period.	Dance video game	31 participants (age 86 - 92). Dance group -15 participants, control group - 16	Foot placement accuracy test, Gait analysis, Gaze behavior, The Falls Efficacy Scale International (FES-I)	There was a significant interaction in favor of the dance video game group for improvements in step time. Significant improved fast walking performance under dual task conditions (velocity, double support time, step length) was observed for the dance video game group only. These findings suggest that in older adults a cognitive-motor intervention may result in more improved gait under dual task conditions in comparison to a traditional strength and balance exercise program.

9.	**The Comparative Study on Improving the Static Balance Ability of the Elderly Female by Taking Tai Chi Chuan and Ballroom Dancing**	Hao, FX (2011)	Intervention program focus on taichinad in control group on ballroom dance	Ballroom dance	132 elderly women, one group of 47 tai chi, ballroom dance group of 40 people, 45 non-exercise group.	Static balance	Differences between groups was significant, which also can be inferred that the social dance of the body movement of the visual system to improve the effectiveness of tai chi exercise on the body than the visual system to improve the effectiveness of social dance movement in static balance ability of older people to improve the way the body mainly by improving the realization of the visual system.
10.	**Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities**	Kattenstroth, JC. Et al. (2010)	No intervention program - the impact of multi-year (average 16.5 years) amateur dancing.	Amateur dance	Dance group 24 participants, 19 female, 72 -74 years) The non-dancer group 38 participants, 30 female (72 - 74 years)	Posture, balance and gait control - Romberg test, reaction times, movement behavior - system MLS, tactile and cognitive performance.	In each of the different domains investigated, the AD group had a superior performance as compared to the non-dancer CG group. We conclude that the far-reaching beneficial effects found in the AD group make dance, beyond its ability to facilitate balance and posture, a prime candidate for the preservation of everyday life competence of elderly individuals.
"dance AND balance abilities AND old age" WOS, 2000 - 2017							
	Title	**Authors**	**Intervention**	**Dance type**	**Participants**	**Methods**	**Results**
11.	**A Novel Video Game-Based Device for Measuring Stepping Performance and Fall Risk in Older People**	Schoene, D. et al.(2011)		Dance video game	47 participants (65 - 90 years)	Test of balance abilities	Dance mat device is a valid and reliable tool for assessing stepping ability and fall risk in older community-dwelling people. Because it is highly portable, it can be used in clinic settings and the homes of older people as both an assessment and training device.
12.	**A novel Dance Dance Revolution (DDR) system for in-home training of stepping ability: basic parameters of system use by older adults**	Smith, S.T. et al (2011)	No intervention program - ability of elderly to use the dance videogame	Dance video games	44 participants (mean age 78)	Step responses by USB DDR mat, characteristics of stepping performance - step timing, percentage of missed target steps and percentage of correct steps were recorded by purpose built software.	Older adults are able to interact with video games based upon DDR but that stepping performance is determined by characteristics of game play such as arrow drift speed and step rate. These novel "exergames" suggest a low-cost method by which older adults can be engaged in exercises that challenge balance and which can be conducted in their own homes.
13.	**Second lives for the third age: Using virtual worlds to encourage exercise participation in older people (P176)**	Heller, B. et al. (2008)	No intervention program - ability of elderly to use the dance videogame	Dance video games	6 participants (ages 80-91)		It appears that older people are able to enjoy interaction with virtual environments, and this, together with appropriate sensors, may be a useful mechanism to motivate exercise in this age group.
"dance AND postural stability AND old age OR elderly" WOS, 2000 - 2017							
	Title	**Authors**	**Intervention**	**Dance type**	**Participants**	**Methods**	**Results**
14.	**Practice of Contemporary Dance Promotes Stochastic Postural Control in Aging**	Ferrufino, L. et al. (2011)	4 months, once a week, 1 hour	Contemporary dance based on movement improvisation	41 participants (60-86 age), contemporary dance group - 16, fall prevention program -25	Techno-Concept platform	Training based on motor improvisation favored stochastic posture inducing plasticity in motor control, while FP training based on more stereotyped behaviors did not.

When searching for dance interventions in the context of balancing abilities, we have analyzed 14 studies. 2 studies observed ballroom dance, 2 Scottish country dance, 4 studies observed dance videogames, 1 contemporary dance a 1 creative dance, waving and senile dance. The style of the dance was not specified in two studies – 1 was called amateur and 1 dance with changing choreographies.

The findings of all these articles show that dance is a movement activity which has positive effects in different parameters. The authors (Dewhurst et al., 2015; Song et al., 2014) compared dance with other movement activities with the focus on balance abilities. The results were always similar, for example Dewhurst (2015) compares dancers with physically active persons. We have chosen also studies for which authors used the dance group as a control group. In an article by Song (2014) in comparison with the experimental group – the group performing tai-chi were comparable only in the short term. For the next 12 months of the intervention the group performing tai-chi (Song, 2014) reported better results in parameters of strength of lower and upper limbs, limb skeletal muscle content and balance ability.

The authors very often used dance programs (Svobodova, 2017) for prevention of falls or they searched for simple testing instruments for operation assessment of function ability at the dance lessons. The authors prove that by using these instruments participants could avoid the falls by movement activities (Bianco et al., 2014).

In our review we have also involved the studies which observe interactive dance pad videogames as a simple and motivating way to incorporate a cognitive element into a physical exercise program – (Heller, Wheat, Mawson, & Wright, 2008; Pichierri, Murer, & de Bruin, 2012; Schoene, Lord, Verhoef, & Smith, 2011; Smith, Sherrington, Studenski, Schoene, & Lord, 2011). Even though an intervention program was not included in every study, this fact seems to be important and interesting. It seems that interactive video games will play a role in the integration of movement programs in the elderly as well.

In some cases (Schoene et al., 2011), dance pad was used as an instrument for assessment of risk of falls in the elderly. An article by Lu et al., 2015 presents an interesting investigation in which magnetic pulse stimulation was included in dance intervention to enhance balance skills as a factor in fall prevention. The results show that positive effect could be even more significant when the dance intervention is combined with magnetic pulse stimulation.

We do not observe the investigations which examine the other effects of the dance on personality, mainly psychological and sociological effects. But we know that these benefits can´t be ignored. This topic appears very often in research (Dosedlová, 2012; West, Otte, Geher, Johnson, & Mohr, 2004; Winkelmann et al., 2004).

Table 3. Summary of Studies Included in the Current Review – endurance and leg strength

"dance AND endurance AND old age OR elderly" WOS, 2000 - 2017							
	Title	Authors	Intervention	Dance type	Participants	Methods	Results
1. (viz. Balance)	Creative Dance Improves Physical Fitness and Life Satisfaction in Older Women	Cruz-Ferreira, A. et a. (2015)	24 weeks series of 50 min	Creative dance	57 women (65-80 years) - experimental and control group	Senior Fitness Test - 30-s chair stand test, 6-min walk test, chair sit-and-reach, 8-ft up-and-go test, BMI	Creative dance has a positive effect in different dimensions of functioning and has the potential to contribute to healthy aging. This could be related to the integrated mobilization of physical, cognitive, and social skills promoted by creative dance.
2.	Effects of dance on physical and psychological well-being in older persons	Hui, E. et al. (2009)	12 weeks, total 23 sessions. 2 sessions of 50 min per week for 6 weeks initially, followed by 2 session per week for another weeks	Low impact aerobic dance	111 participants, 52 EG (68-72 age), 45 CG (69-73 age)	6MWT, trunk flexibility - sit-and reach test, lower limb endurance and strength - sit-and-stand test, balance	Significant difference was observed between the groups in six outcome measures: mean change in resting heart rate, 6MWT, TUG, lower limb endurance and the 'general health' and 'bodily pain' domains of SF-36. The majority of the dance group felt the intervention improved their health status. These findings demonstrate that dancing has physical and psychological benefits, and should be promoted as a form of leisure activity for senior citizens.
"dance AND leg strength AND old age OR elderly" WOS, 2000 - 2017							
	Title	Authors	Intervention	Dance type	Participants	Methods	Results
3.	Social Dancing and Incidence of Falls in Older Adults: A Cluster Randomised Controlled Trial	Dafna M. et al.(2016)	Twice weekly one-hour social dancing classes over 12 month	Folk or ballroom dancing. Participants in the were offered one of two major social dancing styles: Folk dancing - dances from the United Kingdom, United States, France, Italy, Israel, and Greece; or ballroom dancing - dances such as Rock and Roll, Foxtrot, Waltz, salsa, and Rumba.	424 participants in intervention program	PPA - vision (edge contrast sensitivity), peripheral sensation proprioception, lower extremity strength (knee extension), simple reaction time using a figure press as the response, balance, Short physical Performance Battery (SPPB) - tests of side-by-side, semi tandem, and tandem standing for at least 10 s, walking speed over 3 m, and time to complete five chair rises.	Revealed no between-group differences at 12-mo follow-up in the secondary outcome measures. Social dancing did not prevent falls or their associated risk factors among these retirement villages' residents. Modified dance programs that contain "training elements" to better approximate structured exercise programs, targeted at low and high-risk participants, warrant investigation.
4.	Effects of a Salsa Dance Training on Balance and Strength Performance in Older Adults	Granacher U. et al.(2012)	8-week progressive salsa dancing programme - total of 16 sessions by 60 min	Salsa dance	28 participants (63-82 age). 14 - EG, 14 - CG	Static postural control - balance platform, dynamic postural control - walking on an instrumented walkway. Leg extensor power- force plate.	Salsa intervention resulted in a significant improvement in static balance, a significant improvement in walking speed and step length, and decreased step time and no significant change in walking variability and muscle strength of the foot extension.

5.	Effect of a 10-Week Traditional Dance Program on Static and Dynamic Balance Control in Elderly Adults	Sofianidis, G.(2009)	10 week, 2 session per week by 60 min	Traditional Greek dance	14 participants EG, 12 participants CG	Static platform	The dance group significantly decreased COP displacement and trunk sway in OL stance. A significant increase in the range of trunk rotation was noted during performance of dynamic WS in the sagittal and frontal planes. These findings support the use of traditional dance as an effective means of physical activity for improving static and dynamic balance control in the elderly.
6.	Postural stability and physical performance in social dancers	Zhang, JG (2008)	No intervention	Social dancing	202 social dancers and 202 community-dwelling subjects (aged 50–87 years)	Postural stability was examined using the Tetrax System® balance platform, Walking speed, Low back flexibility, Leg reaction time - Motor Choice Reaction Test (MCRT)	Dancers who were older than 60 years had better postural stability and faster leg reaction times, whilst dancers aged 50–59 showed only better flexibility, when compared with the controls. Male dancers had greater low back flexibility and leg reaction time compared to controls. In contrast, female dancers had superior performance only for leg reaction time when compared with controls. Social dancing is associated with enhanced postural stability and physical performance in older adults.

We have been dealing with research results which were focused on the influence of dance interventions on endurance and leg strength of the elderly.

We work with tests which are a part of battery test (Senior fitness test) in our research intention at our faculty. We used 6 min walk test (6MWT) and Chair Stand test. The senior fitness test (SFT) is appropriate for use by health and fitness professionals looking to obtain information about the physical status of older adults either for research purposes or for practical application (Rikli, C. Jessie J., 2012). SFT is very often used in movement activities with the elderly. The purpose of the 6MWT is to assess aerobic endurance, defined as the capacity to perform large-muscle activity over an extended time, chair stand test is focused on assessing the lower-body strength.

We found two articles from the database "Web of science" when searching the key words *dance* AND *endurance* AND *old* age OR *elderly*. An article by Ferreira (2015) deals with both the balance skills (see above) and endurance. A significant difference has been observed between the groups in the research by Hui (2009), the same differences in favor of the dance group in research by Ferreira (2015). Both researchers used 6MWT for testing endurance.

We found four articles when we were looking for intervention dance program for the elderly and the influence on leg strength. The authors use intervention program of social dancing, ballroom dancing, traditional Greek dance and salsa. For the measurement of leg strength different types of balance platforms were used in three studies (Granacher et al., 2012; Sofianidis, Hatzitaki, Douka, & Grouios, 2009; Zhang, Ishikawa-Takata, Yamazaki, Morita, & Ohta, 2008) and in one case the authors (Merom et al., 2016) used sit – and – stand test.

Positive significant effect of the dance programs on leg strength is demonstrated in three studies (Merom et al., 2016; Sofianidis et al., 2009; Zhang et al., 2008) and no significant change was found by Granacher et al.(2012).

Conclusion

Including dance into the offer of physical activities broadens the range of options where everyone can find an activity to match their needs. Dancing has the potential to be an attractive physical activity that can be adjusted to fit a target population's age, physical limitations, and culture.

We agree that as the history of dance is so long, many dance styles have been examined regarding their health benefits, the intensity of loading, energy expenditure as well as mental aspects. Currently new styles are springing up, providing new challenges to revise the effects of dance (Svobodova, 2017). Dance, in addition to physical activity, combines emotions, social interaction, sensory stimulation, motor coordination and music, thereby creating enriched environmental conditions for human individuals. We share the opinion of Dosedlová (2012) that dance is accessible to everyone regardless of gender, age, education, physical and mental health or level of fitness. Dance also transcends language barriers, leads to maximum relaxation and reduces tension.

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PhD. SECTION

NUMBER OF STEPS AND SEDENTARY TIME DURING TWO WEEKDAYS AND TWO WEEKEND DAYS IN 7–10 YEARS OLD CHILDREN WHO DID NOT MEET STEPS/DAY RECOMMENDATION

Bešić Damir, Balaban Vlado
Palacký University Olomouc, Faculty of Physical Culture, Department of Adapted Physical Activities

Abstract

Purpose: In the recent years, children spend most of their waking hours in a sedentary state or in a low level of physical activity (PA), and that might put them at risk of many noncommunicable diseases. Identifying the specific time segment in the week when children show a lack of physical activity and knowledge about proportion of time children spend sedentary is crucial and helpful in organization and development of public health intervention strategies. The aim of this study was to assess the difference between two weekdays and two weekend days considering the number of steps and percentage of time children spent sedentary during waking hours. Further, we investigated the level of correlation between steps/day and sedentary time.

Methods: One hundred and ninety-seven 7–10 years old children, from four elementary schools located in Olomouc, Czech Republic, who did not meet steps/day recommendation, were enrolled in this study. The number of steps and time spent sedentary were monitored for four consecutive days including two weekend days by ActiGraph accelerometers (GT3X, GT3X+). Paired *t*-test was used to assess differences in steps/day and sedentary time between two weekdays and two weekend days and between Sunday and Saturday. Pearson correlation coefficient was used to assess association between steps/day and percentage of time children spent sedentary.

Results: Both boys and girls were significantly more active and took on average two thousand more steps on weekdays compared to weekend. Children from both genders took significantly less steps ($p < .001$) on Sunday than on Saturday. While there was no significant difference between weekdays and weekend days in percentage of time girls spent sedentary, boys spent a slightly larger percentage of time in the sedentary behaviour during weekdays ($p = .009$). Both boys ($p = .005$) and girls ($p < .001$) spent a significantly larger percentage of their waking time in sedentary activity on Sunday compared to Saturday. Time spent sedentary is negatively related to steps/day during in both time sequences, weekdays and weekend, among both genders. The strongest correlation coefficient was found in girls during the weekend ($r = -.73$).

Conclusion: Based on the findings in this study, there is no big differences between two weekdays and two weekend days in percentage of time children spent sedentary.

Children from the current study were less physically active and took less steps during the weekend, while Sunday was the most inactive day. Percentage of time children spent sedentary during waking hours is negatively related to steps/day during both time sequences, weekdays and weekend, in both genders. These findings suggest that the weekend is a crucial time in planning additional activities for increasing PA, while there is a need for decreasing the time children spent in sedentary activity during every day of week.

***Key words**: Physical activity, Middle childhood, ActiGraph, Noncommunicable diseases*

Introduction

Evidence consistently suggests that the appropriate amount of daily physical activity (PA) provides many health benefits for children and youth (Poitras et al., 2016; Strong et al., 2005). The fact is that in recent years, children spend most of the waking hours in the sedentary behaviour or in a low level of PA, that might expose them to the risk of overweight or obesity and might be a reason of onset for many noncommunicable diseases (Carson et al., 2016; Mitchell, Pate, Beets, & Nader, 2013; Straker et al., 2016). While during the schooldays children spend most of the waking time at school environment and their level of PA mostly depends on school-based PA (physical education lessons, PA during short breaks) or on the way of commuting to and from the school, at the same time during a days of weekend children's PA depends on the way how they spend their free time (Sigmund, El Ansari, & Sigmundová, 2012; Vašíčková, Frömel, Groffik, & Chmelík, 2013). Physical activity could have a positive impact on a child's health and prevent the onset of overweight or obesity only if it is performed frequently, with established duration and intensity (World Health Organization [WHO], 2010). Widely used PA guideline is that children and youth should accumulate at least 60 minutes of moderate to vigorous-intensity physical activity (MVPA) each day (Kahlmeier et al., 2015; WHO, 2010). Due to the strong link between steps/day and time spent in MVPA, researchers and practitioners often use steps/day as a criterion for determining whether children and youth are meeting the PA recommendation (Colley et al., 2012). Different propositions exist regarding to how many steps/day are equal to 60 min of MVPA in children and youth. This number ranged between 10,000 and 16,000 steps/day (da Silva, Fontana, Callahan, Mazzardo, & De Campos, 2015). Tudor-Locke et al. (2004) recommended 12,000 steps per day for girls and 15,000 steps per day for boys. The authors concluded that children who failed to meet this steps/day recommendation are more likely to be classified as overweight/obese. There is no strict proposition about what a proportion of total sedentary time during waking hours is preferable for children and for adolescents.

The evidence suggests that any reduction in time spent sedentary during waking hours could have a positive impact on children's health (Tremblay et al., 2016). Identifying specific time segment in the week when children show a lack of PA and knowledge about the proportion of time children spent sedentary is crucial and helpful in organization and development of public health intervention strategies. The percentage of time that children and adolescents spent sedentary during waking hours mainly differ between studies and ranges between 50% and 70% (Colley et al., 2011; Comte et al., 2013; Keane et al., 2017; Riso, Kull, Mooses, Hannus, & Jürimäe, 2016). While among children, there has not been found a difference between week days and weekend in sedentary time, adolescents spend a higher percentage of sedentary time on weekdays (Comte et al., 2013; Riso et al., 2016). Findings from various studies show that children and adolescents are more active on weekdays compared to weekend, and Sunday is the most inactive day in the week (Brooke, Corder, Atkin, & van Sluijs, 2014; Brusseau, Kulinna, Tudor-Locke, Van Der Mars, & Darst, 2011; Vašíčková et al., 2013). Clemes and Biddle (2013) reported that children took on average 20% less steps during weekend in comparison to weekdays. Evidence constantly suggests that between PA and different kind of sedentary behaviour, there is a negative association (Pearson et al., 2014). Strength of this correlation differ between studies and range between small and moderate. The aim of this study was to assess the difference between weekdays and weekend in regard to the number of steps and percentage of time children spent sedentary during waking hours. Furthermore, we investigated level of correlation between steps/day and sedentary time.

Methods

A total of 197 (110 boys and 87 girls) elementary school-aged children, who did not meet recommendation regarding to steps/day, participated in the study. Children, aged from 7 to 10 years of age, have been chosen from four elementary public schools (School 1: boys 24, girls 18; School 2: boys 21, girls 18; School 3: boys 27, girls 23; School 4: boys 38, girls 28) located in the city of Olomouc in the Czech Republic. Sedentary time and steps/day were measured using ActiGraph models GT3X and GT3X+. Children were instructed to wear the ActiGraph on a hip immediately after waking up and to remove it before they go to sleep, with possibilities to take off the device during bath time or other daily activities that could potentially damage it. Data from children who wore the accelerometer for four days (two weekdays and two weekend days) for at least ten hours (maximum thirteen hours) a day were taken into a final processing. Tudor-Locke et al. (2004) steps/day cut-point was used as a criterion by which children were selected to be involved in this study. Only children who on average took less than 12,000 steps and 15,000 steps for girls and boys respectively were included in this study. Tudor-Locke et al. (2004) revealed that children who failed to reach this steps/day recommendation are more likely to be under risk of overweight and obesity. Child's Body Mass Index (BMI) was assessed by the body composition analyser InBody 720 (Biospace Co., Ltd.; Seoul, Korea). Weight status was classified as normal and overweight/obese using international age- and sex-specific BMI cut-off points (WHO, 2006). Before statistics operation all variables were tested for normal distribution by Kolmogorov-Smirnov test. Descriptive analysis (mean, standard deviation and percentage) was performed to describe the sample characteristics. Gender differences were tested using independent *t*-test. Paired *t*-test was used to assess differences in steps/day and sedentary time between two weekdays and two weekend days and between Sunday and Saturday.

Table 1. Descriptive Characteristics (Number, Percentages, Means and Standard Deviations) by Gender

	Boys (n = 110)	Girls (n = 87)	Total (n = 197)
Age years (*SD*)	8.53 (1.11)	8.59 (1.07)	8.56 (1.09)
Body weight kg (*SD*)	31.22 (7.56)	32.61 (9.83)	31.83 (8.64)
Body height cm (*SD*)	136.2 (9.22)	136.9 (10.11)	136.51 (9.61)
BMI (kg/m^2) (*SD*)	16.65 (2.35)	17.22 (3.36)	16.91 (2.85)
BMI normal %	76.15	73.56	74.4
Owerveight/obese %	23.85	26.44	25.6

Note. n = number of participants, *SD* = standard deviation, BMI = body mass index, % = percentage

Cohen's d effect size was used to assess the strength of differences: d = 0.2 small effect, d = 0.5 medium effect, and d = 0.8 large effect (Cohen, 1992). Pearson correlation coefficient was used to assess association between steps/day and percentage of time children spent in sedentary behaviour. The strength of the correlation between observed values is evaluated by Cohen's criteria: r < .3 = small, $.3 \geq r < .5$ = medium, $r \geq .5$ = large (Cohen, 1992). Separate analyses were performed for boys and girls. Statistical significance was accepted at $p < .05$. All statistical analyses were performed using the software STATISTICA v.12 (StatSoft, Prague, Czech Republic).

Results

In Table 1. (see above), there are presented anthropometric characteristics of children included in this study. Independent *t*-test show no gender differences related to age, weight, height or BMI variables. In total, 25.6% of all children were characterized as overweight or obese. Results from independent *t*-test indicated that significant difference ($t(195) = 2.41$, $p = .017$, $d = 0.35$) between boys ($M = 9{,}753$, $SD = 2{,}277$) and girls ($M = 9{,}027$, $SD = 1{,}858$) was in relation to the number of steps that children took during four days (two weekdays and two weekend days). Gender-based differences in steps/day and sedentary time during two weekdays and two weekend days are presented in Table 2 (see below). Small effect size ($d = 0.25$) but no significant difference ($p = .09$) was found between boys ($M = 8{,}662$, $SD = 2{,}711$) and girls ($M = 7{,}982$, $SD = 2{,}760$) in steps/day during weekend. Paired *t*-test revealed that both boys ($t(109) = -6.16$, $p < .05$, $d = 0{,}7$) and girls ($t(86) = -6.01$, $p < .05$, $d = 0.88$) were significantly more active and took on average 2,000 more steps on weekdays compared to weekend. Children from both gender took significantly fewer steps on Sunday (boys $M = 7{,}820$, $SD = 3{,}333$, girls $M = 7{,}098$, $SD = 3{,}061$) than on Saturday (boys $M = 9{,}895$, $SD = 4{,}272$, girls $M = 8{,}983$, $SD = 3{,}326$) with moderate effect size (boys $d = 0.54$, girls $d = 0.59$). Boys ($t(109) = -2.66$, $p = .009$, $d = 0.25$) spent significantly more waking time in sedentary activities during weekdays ($M = 52{,}7$, $SD = 9.16$) than on weekend ($M = 50.4$, $SD = 9.22$) but effect size was small ($d = 0.25$). There was no significant difference between two weekdays and two weekend days girls spent sedentary during waking hours. Results from paired *t*-test indicated significant differences in time spent sedentary over weekend days in both genders. Both boys ($t(109) = -2.84$, $p < .05$, $d = 0.29$) and girls ($t(86) = -3.65$, $p < .05$, $d = 0.38$) spent significantly more waking time in sedentary activity on Sunday compared to Saturday. Based on the results of the study, time spent sedentary is negatively related to steps/day during both two weekdays and two weekend days, in both genders (see Table 3 below). The strongest correlation coefficient between sedentary time and steps/day was found in girls over two weekend days ($p < .05$, $r = -.73$).

Table 2. Difference Between Two Weekdays and Two Weekend Days in Steps/Day and Percentage of Time Boys and Girls Spent Sedentary

	Boys (n = 110)			Girls (n = 87)		
	Two weekdays	Two weekend days	Cohen's *d*	Two weekdays	Two weekend days	Cohen's *d*
Steps/day (SD)	10,606 (2,844)	8,662* (2,711)	0.71	10,194 (2,220)	7,982* (2,760)	0.88
Sedentary time %	52	50*	0.25	54	54	0.04
	Saturday	Sunday		Saturday	Sunday	
Steps/day (SD)	9,895 (4,272)	7,820* (3,333)	0.54	8,983 (3,326)	7,098* (3,061)	0.59
Sedentary time %	49	52*	0.29	51	56*	0.38

Note. n = number of participants, *SD* = standard deviation, % = percentage, * = $p < .05$.

Table 3. Correlation Between Steps/day and Percentage of Time Boys and Girls Spent Sedentary

	Boys	Girls
	Steps/day two weekdays	
Sedentary time two weekdays	-.51*	-.46*
	Steps/day two weekend days	
Sedentary time two weekend days	-.55*	-.73*

Note. Values are presented as a Pearson's correlation coefficient r, * = $p < .05$.

Discussion

The main aim of this study was to assess the difference between two weekdays and two weekend days in regard to the number of steps and amount of time children spent sedentary during waking hours. Furthermore, we investigated the level of correlation between steps/day and sedentary time. Both boys and girls from the present study were significantly more active on weekdays compared to weekend. Children from both genders took significantly less steps on Sunday compared to Saturday. While there was no significant difference between weekdays and weekend days in percentage of time girls spent sedentary, boys spent a slightly larger percentage of time in sedentary behaviour during weekdays. During Sunday children spent a significantly larger percentage of their waking time in sedentary activity compared to Saturday. Results from present study showed that time children spent sedentary is negatively related to steps/day during both time sequences, weekdays and weekend, in both genders. To date, many different recommendations about how many steps/day is enough for children, have been suggested. This brings upon a dilemma for researchers and practitioners which steps/day cut point to use. For the present study, steps/day recommendation proposed by Tudor-Locke et al. (2004) was used to determine the threshold based on children were chosen to be involved in this study. Only children who took on average less than 12,000 steps and 15,000 steps for girls and boys respectively were included in this study. This number of steps are equal to 60 minutes of MVPA what is widely used proposition in regard to the amount of time that children should spend on most days of the week to reach a health benefits from PA (Tudor-Locke et al., 2004). Tudor-Locke et al. (2004) revealed that children who failed to reach this steps/day recommendation are more likely to be under risk of overweight and obesity. Sigmund and Sigmundová (2014) proposed the same number of steps/day for the Czech girls, while for the Czech boys, these authors recommended 1,000 steps less than Tudor-Locke (2004). Using Tudor-Locke steps/day cut points we found out that 25.6% of children, who did not reach this recommendation, were obese or overweight. It should be mentioned how insufficient PA is not the only factor that contributes in onset of overweight/obese. One of the reasons, why children from the current study did not reach the steps/day recommendation could be that the present study was conducted during a winter period in which the children do not have enough opportunity for their outdoor activities and they are more likely to be physically inactive. Evidence constantly shows that besides daily lack of PA, simultaneously, time spent sedentary also could affect children's health in many ways (Tremblay et al., 2016). Even if children reach steps/day recommendation, there is still a potential danger for child's health if they spend most of the waking hours in sedentary behaviour (de Rezende, Lopes, Rey-López, Matsudo, & do Carmo Luiz, 2014). To date, there is no strict recommendation in regard to optimal proportion of the waking time that children and youth should spend in sedentary behaviour to minimize its negative effect on health. Mostly, authors and practitioners support suggestion that during the waking time, children should spend as little time in sedentary activity as it is possible (Tremblay et al., 2016). To minimize the chance of negative influence of sedentary behaviour on health, in recent period, the recommendation is widely used that children and youth should spend less than 2 hours a day in screen time sedentary behaviour (Trembley et al., 2016). Interesting is that children from our study spent almost the same amount of waking time in sedentary activity as their counterparts from Canada and Estonia (Colley et al., 2011; Riso et al., 2016). Also, same as in our study, there were no gender differences among Canadian and Estonian children in time spent sedentary. In studies conducted on adolescents, there has been found that they spent more time in sedentary activity than the younger population (Colley et al., 2011; Comte et al., 2013). Little evidence exists about a percentage of the waking time that Czech elementary-school-aged children spend sedentary during various time segments in a week. The fact that many studies analysed sedentary behaviour in adolescents or sedentary behaviour was measured through screen based activities or time spend sedentary is measured by a questionnaire, complicate comparisons of our results with the findings from other studies. Our results in regard to difference between week days and weekend days in percentage of time boys and girls spent sedentary correspond with findings reported by Collings et al. (2014) and show that boys spent a significantly higher percentage of waking time sedentary on weekend compared to weekdays, while at the same time girls spent almost the same amount of time in sedentary activity during both time sequences, over weekdays and weekend. This comparison should be considered with caution, because Collings et al. (2014) conducted study on adolescent population. Results from the present study correspond with findings from a study conducted by Keane et al. (2017) and show no or little difference in the time elementary-school-aged children spend sedentary during weekdays compared to the weekend. Same as in the study conducted by Collings et al. (2014), the analysis of child's weekend PA behaviour in present study revealed that during a Sunday, children spent significantly more time in sedentary behaviour and took less steps compared with Saturday. The same as the results from studies conducted by Brooke et al. (2014), Brusseau et al. (2011) and Vašíčková et al. (2013) findings from present study show that both gender, independently of the weight status, were significantly less active on weekend compared to weekdays. Our findings show that boys took 22%, while girls took almost 28% less steps during weekend compared to weekdays, which is a bit larger percentage than is reported in the study conducted by Clemes and Biddle (2013). Both boys and girls from the present study, took about 2,000 steps less and spent a larger percentage on sedentary time on Sunday compared to Saturday. The similar finding has been reported from a study conducted by Vašíčková et al. (2013) in which the Czech and Polish adolescents took on average fewer steps on Sunday compared to other days of the week. Findings from our study correspond with the suggestion that between PA and time children spend sedentary, there is a negative correlation (Pearson et al., 2014). In our study, the strength of this correlation ranged between medium and large and showed a higher coefficient than Colley, Janssen, and Tremblay (2012) reported from their study. Our results showed that by increasing steps/day in both gender, especially in girls during weekend, decreased the amount of time children spend sedentary.

Conclusion

Based on the findings in this study there are no big differences between two weekend days and two weekdays in the percentage of time children spent sedentary. Both, boys and girls were less physically active and took significantly less steps during two weekend days compared to the two weekdays. During Sunday, children spent significantly more time in sedentary behaviour and took fewer steps in comparison to Saturday. Percentage of time children spent sedentary during waking hours is negatively related to steps/day during both time sequences, weekdays and weekend, in both genders. Our results confirm the suggestion that weekend is a crucial time in planning additional activities for increasing PA and decreasing time children spend sedentary. It should be noted that the target of PA intervention in children who are under risk of noncommunicable diseases should not be limited only to weekend. In order to decrease time children spend sedentary and increase steps/day, there is a need to constantly promote an active lifestyle during the whole week.

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FOSTERING INTRINSIC MOTIVATION AND SATISFACTION WITH TRAINING SESSIONS AMONG SPORTING CHILDREN AND YOUNG ADULTS

Blažej Adam
Department of Social Sciences and Sport Management, Faculty of Sports Studies, Masaryk University Brno, Czech Republic

Abstract

The contribution deals with a creation of a motivational climate from a point of view of children and young adult's category members coach and which should result both in the fostering of intrinsic motivation and enhancing of satisfaction with training sessions. Children and youth athletes require a different approach than adults in a matter of motivation as well as a matter of satisfaction and this is the reason why some trainers tend to fail in the preparation of training unit.

There is a number of studies about these topics, but there are basically a little bit of comprehensive materials that can be used in practice. So this contribution therefore has a review character with the review question: Are there communication techniques and techniques for preparation of training unit that enhances satisfaction and intrinsic motivation among sporting children and youth?

Data will be extracted from studies that include areas of pedagogy, psychology, management and environment of sport by following keywords: motivation, intrinsic motivation, external motives, satisfaction, children, youth and physical activities. Data will be synthesized by a narrative summary.

Parts of the output are also practical examples of how psychologically affect children and young adults in sport. So this paper details techniques of creating exercises from psychological point of view, including the use of external and internal motives, as well as communication techniques that have an impact both on intrinsic motivation and satisfaction with training sessions. The basics of these techniques should know every trainer because psychological component plays a crucial role not only in sport performance but can also have far-reaching consequences for the future career of an athlete.

Key words: *motivation, intrinsic motivation, external motives, satisfaction, children and youth, preparation of training unit, physical activities*

Introduction

Achieving a master level at any type of sport is grounded in the early career of each athlete. These basics for the future career of an individual athlete are in the greatest extent built by coaches that a young athlete encounters in his early beginning. However, a great number of young athletes do not develop proper mental development habits, which lead them to the point of a low entertainment, low internal motivation in the sport activity and later on they might quit (or do not improve their skills at all).

For this reason, it should be crucial for a coach to focus on creating a motivational climate, which will lead to an athlete's satisfaction fulfilling training sessions (despite the difficulty of the training unit) and, on the other hand, will foster the individual's inner motivation.

The following rows will introduce a number of techniques and tools as a theoretical way how to create a motivational climate developing satisfaction with training sessions and fostering intrinsic motivation in young athletes.

Methods

Review question: Are there communication techniques and techniques for preparation of training unit that enhances satisfaction and intrinsic motivation among sporting children and youth?

Review criteria: Review will consider including studies that will contain techniques for fostering intrinsic motivation and satisfaction by using external motives and such communication techniques that are scientifically confirmed. These studies will be extracted from environments of sport, pedagogy, psychology and also management by following keywords: motivation, intrinsic motivation, external motives, satisfaction, children, youth and physical activities.

Synthesis: Data will be synthesized by a narrative summary.

Techniques and tools fostering intrinsic motivation among sporting children and young adults

From a psychological point of view, research confirmed number of tools and techniques showing effective communication styles and also the construction of training session that can deepen athlete's desire to improve. It is known that this desire is largely conditioned by the satisfaction with the training session.

Provide a choice and control over the course of activity

The research (Alderman, Beighle & Pangrazi, 2006) confirm the following: students who can choose from multiple exercise options were much more motivated to carry on the activity than a students, who were essentially forced, because they had no other choice. This knowledge can be applied for coaches and trainers, who give our athletes a chance to make a choice of exercise during training session. The theory of choices during the training unit and the consequent increasing the desire is confirmed by Pangrazi's research (2001). Pangrazi offered an opportunity for the ice hockey players to practice their shoots in two ways. After then, there was a much more effort to train a certain type of shooting when players could choose (In Alderman, Beighle & Pangrazi, 2006).The principle of this method consists in transferring responsibility for the quality of the activity which results in a need to try harder.

The external motives use

According to the theory of cognitive evaluation formulated by Deci and Ryan (1985), the use of external rewards may weaken intrinsic motivation. Referring to the research, Deci and Ryan said: "*When rewards are paid in the same way as feedback is given to people to acknowledge their effort and are spontaneously experienced than it is possible they will maintain or strengthen the intrinsic motivation. However, when rewards are paid to motivate people, who are forced to do their job, it can lead to weakening of intrinsic motivation* (In Armstrong & Taylor, 2015). It means that intrinsic and extrinsic motives are not "antagonists", but they coexist and thus completion of the motivational scheme by external motives increase intrinsic motivation rather than decrease (Hayamizu, 1997). However, they must be used properly.

According to a study (Harris D. & Harris B., 1984), the athletes' commitment rate can also increase if the time spent by tries and the huge sacrifice he has brought into his efforts are publicly valued – when his actions are positively evaluate by society (In Vičar, 2016).

For coaching, this information can be used by using praise, reward, or other external motives spontaneously to evaluate the athlete's effort after finishing exercise (or their greatly improved performance) – not to use them as a reason for good performance.

Effective feedback

Lahner (2012) recommends the so-called *"sandwich"* method when giving feedback. That means wrapping the negative part between two positive. A goal of this method is to leave a positive feeling (creating a positive memory due to using a praise at the very end of the critique) even though he will be informed about his mistakes. However, the *"sandwich"* method has its own imperfections and should not be used in all cases. According to a Finkelstein and Fishbach (2012) experts and professionals as recipients of feedback do not mind hearing only negative criticism without *"wrapping*" because they are aware of their qualities and have sufficient self-confidence to accept criticism. For children, however, these qualities and self-confidence cannot be expected.

Very important is also a feedback, which should be linked to an activity, not to a person. So when coach want to give a feedback, he should do it in a way like *'you did not prepare so much obviously', 'you really tried'*, *'you did a great job'*, or *'it´s obvious, you really know what you are doing'*. On the other hand every coach should avoid both criticism and praise linked to a personal characteristics, such as *'you are smart'*, or *'you are stupid'*. (Kamins & Dweck, 1999). In a case of young athletes´ bad performance Hall & Goetz (2013) recommend to say: '*they have not tried sufficiently'*. It is known; this type of feedback generally leads to a greater persistence and feeling that the athletes have much more control over their abilities.

Coaches and educators should also avoid providing feedback based on comparison to the environment or society. For example, instead of *'you're worse / better than ...'* etc., it is recommended to use a rating in the sense of *'perhaps you need more experience to solve this problem'*.

Last but not least, it is also crucial to avoid giving feedback based on regret. Although we feel the sorrow over our young athlete´s bad performance our feedback should not be based on regret. If we do so, we might show him that our expectations in his abilities are very low. Even in this case, our feedback should contain a slight disappointment about the performance. Described approach will show the fact that we believe in his progress in future. For example of this kind of feedback we can use *'You simply did not give it all. I know you can try harder!*' (Hall & Goetz, 2013).

Don´t emphasize the result

Statements like '*this test will make 25% of your final mark'*, or *'your performance in this test will be very important for your future study life'*, may have a significant motivational and emotional impact on students. On the one hand, they strongly support the need to work hard for the given task (test, exercise…) – based on creating positive emotions when the goal is reached – but on the other hand they also increase possibility of creating the negative emotions before, during and after exercise such as anxiety, concern, or anger. It is generally recommended that these statements should not be used for students, whose self-esteem is low.

Emphasize overcoming oneself, not others

Emphasize the result can also have a negative effect if "motivational" statements include measurement with the environment or peers. For example statement like *'we will see who is the fastest'* will boost the motivation and then pride to the winner, but the rest of the team will experience a feeling of a disappointment. This behaviour might be generally considered as a bringing negative value to the team. Instead of the aforementioned statement, it is recommended to use this; for example: '*How many times do you XYZ in thirty seconds?'* (Hall & Goetz, 2013).

Increasing satisfaction from training session

Training sessions for children and young athletes should be conceived primarily in the form of games in order to enjoy sporting activities. This approach, however, does not always contain results in equally effective results in terms of performance and progress as physically demanding and 'drill' training units. But even in case of these training units, the negative feelings that the athletes can take away from them, can be minimized.

The positive way of ending of training session

Even a changing the way of ending a training session could lead to the overall satisfaction of the young athletes - with that session despite physically or psychically demanding exercises (but necessary for the progress of players). This hypothesis was investigated with using a study (Kahneman & Redelmaier, 1996) conducted on patients, whose treatment procedure was finished in two ways - very painful and almost painless. The procedure of first group of participants (very painful way of treatment) was shorter and less painful, more positive memories from the procedure experienced the second group of participants (almost painless). It is due to an almost painless end of the procedure (although it last much longer and the overall were more painful). This theory is known as '*peak-end theory'*.

In coaching practice, this information can be used at preparing training session, which in the case of a physically and psychically demanding exercises the funny (or just favourite among children) part will be used at the very end of the session.

Enthusiasm

It is known that emotions are contagious and can be transmitted through social interactions. It is logical to think the young athletes are significantly influenced by the emotions of their coach. Both the negative (anger, fear…) and the positive ones (joy, pride…). If we can clearly see a trainer's enthusiasm, there is a big possibility of sharing his positive approach with his students. (In Hall & Goetz, 2013).

Results

Table 1. Techniques and tools fostering intrinsic motivation among sporting children and youth

Method / tool	**Description**
Provide a choice and control over the course of activity	*Allow your young athletes to choose an exercise during the training session.*
The external motives use	*Use external motives (rewards) only spontaneously after good performance. Not as a major motive for doing activity.*
Feedback – "sandwich" method	*Provide feedback (criticism) in the form in of putting negative information between two positive (praise).*
Feedback linked to an activity, not a person	*Provide feedback (criticism) in the form of linking our statement to the activity, not a person (You did a great job. / You have to try harder.).*
Not giving a feedback linked to an environment, society, or peers	*Don´t compare your athletes with other peers (or society generally). Avoid using statements like 'you're worse / better than...' Use for example 'you need more experience to solve this problem' instead of.*
Not giving a feedback based on regret	*Don´t regret your athletes in the case of failure. Prevent communication in the way of not believing in him anymore. Show your disappointment slightly.*
Don´t emphasize on result	*The pressure we put on the importance of the result could affect the most negatively students with a low-self esteem. Otherwise, this technique may be used (but rarely in the case of children).*
Emphasize on overcoming oneself, not others	*Instead of saying 'We'll see who's going to be the fastest!' (There is only one winner, and it's obvious that others have lost.), it's psychologically more effective to use, for example, 'How many times can you make XYZ for thirty seconds?'(Which could be followed by a reward for possible personal improvement.)?*
Increasing satisfaction from training session	
The positive way of ending of training session	*Use players´ favourite (funny) exercise at the very end of the training session in the case of both physically and psychically demanding training session.*
Enthusiasm	*Show your emotions and desire. Enjoy being a coach and working with children and young athletes in the kind of sport you like.*

Discussion

The output of this article can be considered as incomplete because techniques and tools to foster intrinsic motivation (and satisfaction with training session) might be countless. And this is the reason why all coaches, trainers, and scientists on fields of kinesiology and sports psychology should therefore be constantly studying the possibilities of fostering intrinsic motivation of children and young adults. Results of a mentioned studies are also showing, there is nothing like one universal and right model for a constructing a training session. Every each of students is individual with a specific character, habits and behaviours. It is necessary for trainers and coaches to train them individually.

Conclusion

Only a deeply intrinsic motivated person has very big a need to try to be the most successful in his kind of sport. And from position of coach or trainer it is crucial to induce that kind of motivation. Not just because of achieving mastery level. It is also necessary to increase satisfaction from physical activity because the basics that will get children in the early career will be accompanied throughout their physically active lives.

This article, or its recommendation, should be used only as a summary of how to approach children and young adults, or how to prepare training session from psychological point of view. Their use may partially remove the negative effects based on the coach's personality, which the athletes cannot affect at all. It also necessary to remember - children should only do the kind of activities they really enjoy (and shouldn´t be forced to do it). If we give them a motivational climate they need, they will also reach the highest degree of positive emotions, such as greater desire, and a greater sense of satisfaction from practicing physical activities (In Deci, Vallerand, Pelletier & Ryan, 1991).Thus, all assumptions of a sought-after intrinsic motivation, which is not appreciated for the emotional state itself, but for its far-reaching positive future consequences.

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RELATIONSHIP BETWEEN MAXIMUM LEG CURL/KNEE EXTENSION PERFORMANCE AND 10M SPRINT PERFORMANCE OF AMATEUR SOCCER PLAYERS

Bokůvka Dominik, Cacek Jan, Hlavoňová Zuzana, Nykodým Jiří, Vencúrik Tomáš
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Speed is an inherent component of the overall players' performance in soccer, where acceleration speed is one of the most abundant types of speed skills used in the game. When sprinting, whole set of muscles is employed. Quadriceps muscles functioning as a knee extensors play fundamental role during the acceleration phase of a run, particularly in the support and driving phase of the movement. Previous findings suggest that there is a positive relationship between maximum strength level of lower extremities and sprint performance. Nevertheless, these studies used multi joint exercises when measuring the maximum strength level. In contrast, our study focused on single joint exercises engaging predominantly hamstring and quadriceps muscle groups. This study comprised 31 amateur soccer players (mean (SD) age 22.2 (± 2.2) years, height 180.9 (± 6.7) cm, weight 76.9 (± 7.6) kg) who were assessed for maximum knee extension, maximum leg curl and 10m sprint test. Maximum bilateral strength was measured according to Baechle's protocol, using Grün sport workout machines. The 10m sprint test was conducted indoors, using Brower Timing TC-System. We found no significant linear correlation ($p < 0.05$), between the maximum knee extension performance and 10m sprint performance ($r = 0.08321$), as well as between the maximum leg curl performance and 10m sprint performance ($r = 0.2945$) of the soccer players. This result is contradictory to the previous findings which observed correlation between maximal strength and speed performance. We assume that knee extension and leg curl exercises are very specific, single joint exercises, and as such, recruit only a limited number of structures. Hence, we do not recommend to use solely knee flexion/extension strength tests to predict the level of speed skills. We suggest that more complex testing and training exercises should be utilized for strength evaluation when working with soccer players.

Key words: *soccer, maximum strength, leg curl, knee extension, acceleration, 10 m sprint*

Introduction

In many sports, athlete's performance is determined by an actual level of various speed skills. Soccer is a multifactorial game where speed skills play a substantial role. According to Kirkendall (2011), the sprint length in soccer varies between 9 to 27 metres and sprints are repeated every 45–90 seconds, with the overall distance covered by a sprint ranging from 730 to 910 metres. Psotta (2006) sees starting speed and running acceleration as one of the most important speed components of a player's profile, demanding that players frequently produce short bursts of maximum power in a very short time (Perič & Dovalil, 2010).

Individual knee flexors and extensors of the thigh muscles play crucial roles in knee joint energetics, which are required for appropriate execution and stabilization of the stance, swing and flight phases of running (Yeow CH, 2013). Therefore, certain strength level of knee extensors (quadriceps) and knee flexors (hamstring) is required for the players to be able to carry out maximum speed actions. In particular, hamstring (semimembranosus, semitendinosus, biceps femoris long and short-heads) strength is believed to be essential for sprinting performance in soccer (Bračič, Hadžič, Čoh, & Dervišević, 2011; Lockie, Schultz, Jeffriess, & Callaghan, 2012), specifically during the late swing and terminal stance phase of the running cycle (Schache et al., 2011). On the other hand, quadriceps muscles (rectus femoris, vastus medialis, vastus intermedius and vastus lateralis) are responsible for energy dissipation during the flexion mode of the swing phase, hip flexion to lift the leg for forward swing and also for the knee extension during the late swing (Gazendam & Hof, 2007).

There are plenty of works investigating the relationship between strength and sprint performances (Comfort, Pearson, & Bullock, 2012; Clark, 2016; Cronin & Hansen, 2005; McBride et al., 2009). At the same time, various approaches have been demonstrated in these studies to examine strength performance. Some researchers adopt multi-joint exercises when measuring strength, other exploit single-joint tasks employing only a limited number of structures. Clark (2016) and Jenkins & Blazevich (1998) used isokinetic devices, whereas Harris, Cronin, Hopkins, & Hansen (2008) used squat machines in their research. Other authors (Comfort et al., 2012; Cronin & Hansen, 2005; McBride et al., 2009; Wisløff, Helgerud, Hoff, Castagna, & Jones, 2004) used free weight when examining the relationship between strength and sprint action. The squat performance was examined in a study of Comfort, Haigh, & Matthews (2012), where an increase in squat performance resulted in enhancement of running speed. Data collected by Chelly et al. (2010) also show similar findings and indicate positive correlation between resistance training and sprint performance. Very positive relationship has been observed especially between free weight squats and sprint performance.

A study by Wisløff et al. (2004), for example, investigates the relationship between maximal strength and sprint performance of 17 professional soccer players. Results of this work suggest that there is a positive correlation between 1 repetition maximum (1RM) squat performance and 10m speed test. Similarly, Comfort, Stewart, Bloom, & Clarkson (2014) found a moderate-to-strong inverse relationships between strength and sprint times in their research, stressing the importance of developing high levels of lower-body strength to enhance sprint performance of soccer players. In contrast, Harris et al. (2008) found only a weak correlation between machine squats and sprint times of athletes. Another study of Askling, Karlsson, & Thorstensson (2003) confirmed improvement of speed skills and reduction of hamstring strain injuries after a 10-week specific hamstring training.

The aim of this study was to determine the relationships between maximal leg curl (knee flexion) and knee extension performances and 10m sprint performance in amateur soccer players. It was hypothesized that there would be certain relationship between maximal knee flexion and knee extension performance and 10m sprint, similarly to previous findings identified by Comfort et al. (2014) and Wisløff et al. (2004) in squat exercise.

Methods

Experimental approach to the problem. This study was designed to investigate the relationships between maximal leg curl/knee extension strength and sprint performance (times over 10m sprint) in well-trained (>3 times per week for more than 5 years) amateur soccer players. Sprint performance over 10m was selected because this is a representative sprint distance covered during real games, where acceleration speed plays a major role. After data collection was finished, relationships between dependent variables were determined via Pearson's correlations.

Subjects. Mature male soccer players (n = 31; age 22 ± 2.2 years; height 180.9 ± 6.7 cm; weight 76.9 ± 7.6 kg) participated in this study. All players were given entire information about the study beforehand, Afterwards, they signed an informed consent to participate. The examination was approved by institutional review board as well. Testing was conducted in the mid-season period where all the players were exposed to at least 4 soccer-specific training sessions per week. At the time of testing, all subjects were fully rested and were advised to come in a fed and hydrated state. Subjects were also instructed not to consume any drugs, alcohol or supplements 24 hours prior to the testing.

*Procedure***.** On arrival, all players had their height (Stadiometer; Seca, Birmingham, United Kingdom) and weight (InBody 720; Cerritos, CA 90703, USA) measured wearing only their underwear. A standardized warm-up was applied before the tests in order to improve the reliability of the tests. Warm-up included 10 minutes of jogging/cycling followed by dynamic stretching exercises and muscle activation exercises. Additionally, sprint tests were preceded by three 5m sprint runs.

*Speed***.** All subjects completed 3 trials of the 10m sprint initiated from a standing start, with a 3-minute rest between each trial. Only the best performance of the 3 trials was counted and used for data analysis. The test was conducted indoors and the time was measured by Brower Timing TC-System (Brower Timing Systems; Draper, Utah, USA), using the TC-Motion Start device enabling the subjects to start anytime they wanted.

Knee extension/leg curl. Speed test was followed by maximum bilateral strength tests that were conducted in a gym. First of all, we instructed the participants about proper technique of the respective exercises. Further familiarisation comprised of a specific warm-up of 10 repetitions with a light-to-moderate load. Participants were first tested for their knee extension maximum strength, moving to the leg curl maximum strength measurement afterwards. The 1RM was tested on Grün sport (Horní Bříza, Czech Republic) workout machines. We used Baechle's protocol (Baechle & Earle, 2008) as a procedure for stating bilateral 1RM for each exercise.

All assessments took place on the same day, in the sequence described above, with approximately 10-minute rest between assessments. All subjects were tested in the morning of the same day.

Statistical analyses. When analysing the data, we used STATISTICA (StatSoft, Inc., Tulsa, USA). In order to test normal distribution of the sample, we used Shapiro-Wilk test of normality. Based on the results of this test (knee extension: $p=0.16$; leg curl: $p=0.57$; 10m sprint: $p=0.84$) we used parametric Pearson's correlations to determine relationships between the variables.

Results

The following results were obtained: mean (SD) age 22.2 (± 2.2) years, height 180.9 (± 6.7) cm, weight 76.9 (± 7.6) kg. The mean time taken for the 10m test was 1.84 (0.07) seconds. The mean 1RM values for knee extension and leg curl were 76.21 (12.6) kg, 71.92 (11.02) kg respectively. The values of 1RM did not correlate with the 10m sprint time ($r=0.08$, $p<0, 05$, fig. 1 for knee extension; $r=0.29$, $p<0.05$, fig. 2 for leg curl). The performance in 10m sprint was found linearly independent on the 1RM values of knee extension and leg curl exercise.

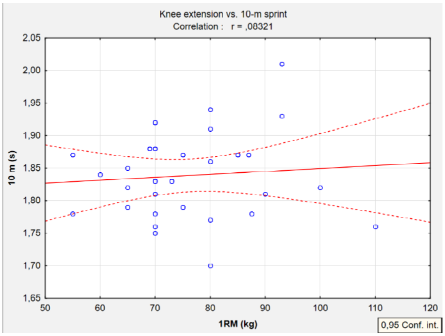

Figure 1: Scatter plot: Knee extension 1RM (kg) vs. 10m sprint performance (s)

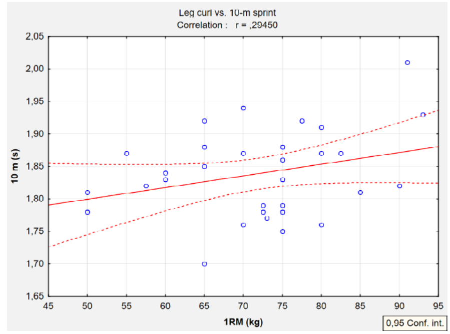

Figure 2: Scatter plot: Leg curl 1RM (kg) vs. 10m sprint performance (s)

Discussion

Contrary to our hypothesis, the results show no significant relationship neither between maximal knee extension and 10m sprint ($r=0.08$, $p<0.05$), nor between leg curl and 10m sprint performance ($r=0.29$, $p<0.05$). The results contrast some of the previous studies concerning similar problematics (Comfort et al., 2014; Wisløff et al., 2004). McBride et al. (2009), on the other hand, failed to find significant relationship between strength and 5-yard sprint performances in well-trained athletes, which is in line with our conclusion. The results of our study indicate that no linear correlation exists between maximal strength of quadriceps or hamstrings and 10m sprint run in amateur soccer players, despite the fact that peak ground reaction forces and impulse are strong determinants of sprint performance (Hunter, Marshall, & McNair, 2005; Weyand, Lin, & Bundle, 2005). Delecluse et al. (1995) suggest that maximal strength training alone appears to be insufficient to improve power and sprint performance. Our work used single-joint tasks (bilateral knee extension and bilateral leg curl) where limited number of structures (quadriceps and hamstrings predominantly) is recruited and that is where we understand the contrast in results when compared to some of the previous studies. In addition, Delecluse (1997) and Adams, O'Shea, O'Shea, & Climstein (1992) recommend that strength training should be combined with sprint running training program when improving speed skills. This idea is supported by Marques et al. (2015), who, in order to improve short-sprint performance, applied either strength training, or sprint running regimen, or combined, to physically active subjects and reported positive results in all the groups, with superior results obtained in the one where combined strength and sprint running training was performed. Even though plentiful research (Comfort, Haigh, & Matthews, 2012; Cronin & Hansen, 2005; McBride et al., 2009; Wisløff et al., 2004) illustrate the importance of developing high levels of strength to enhance sprint performance, we do not recommend to use single-joint lower-limb exercises. Moreover, the authors of studies with positive results acknowledge that a strong correlation does not imply cause and effect. We also suggest not to measure strength using non-specific exercises in order to predict speed skills in football. The level of 1RM measured in tasks where isolated quadriceps or isolated hamstrings are exploited does not predict the level of speed skills, particularly in 10m sprint.

Conclusion

We assume that knee extension and leg curl exercises are very specific, single joint exercises, and as such, recruit only a limited number of structures. Hence, we do not recommend using solely knee flexion/extension strength tests to predict the level of speed skills. We suggest that more complex testing and training exercises should be utilized for strength evaluation when working with soccer players.

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THE EFFECT OF BABYWEARING ON MATERNAL GAIT: A CASE STUDY

Gimunová Marta, Kolářová Kateřina, Zvonař Martin
Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: Babywearing is getting popular among the parents and caregivers as it provides a close physical contact and stimulations for interaction with the baby. Changes in gait kinematics of the female carrier were described previously; however, the number of studies is limited. Therefore, the aim of this study was to compare the longitudinal maternal gait changes during pregnancy, postpartum period and postpartum during the front wrap and back wrap babywearing condition.

Methods: One pregnant women was measured longitudinally. She participated at the data collection at the 16 and 38 weeks of gestation and 8 months after delivery. Additionally, at the last data collection session a front wrap and back wrap babywearing were used. At each data collection, the participant was asked to walk barefoot trough a 7 meters long pathway in a space captured by Simi Motion system at her preferred speed wearing retro-reflexive markers. Following variables were analysed: step width, step length; maximal hip extension; maximal hip flexion; knee joint height, maximal knee extension; maximal knee flexion, trunk left-right motion and trunk anterior-posterior motion.

Results: For purpose of this study, the 16 gestational week simulated the pre-pregnancy gait pattern. In the last trimester of pregnancy, increased hip flexion and lateral and anterio-posterior shifting of the body and decreased knee flexion and stride length were observed, confirming findings of previous studies. Six months postpartum spatio-temporal and most of the kinematic gait characteristics returned to pre-pregnancy values. Changes in the gait pattern induced by the front wrap babywearing were similar like the 38 g.w. of pregnancy condition. However, a decrease in the maximal knee flexion and lateral trunk motion and increase in step length were observed during the front wrap compared to the advanced pregnancy. During the back wrap babywearing condition compared to the advanced pregnancy data collection session an increase in maximal knee flexion, maximal knee high and step length and decrease in maximal anterio-posterior trunk motion, step width and maximal hip flexion were observed.

Conclusion: Results from this study confirm that most of the changes in the gait during pregnancy return back to the pre-pregnancy levels postpatrtum. Changes of the maternal gait induced by both, the frontal and back wrap babywearing were described in this study.

***Key words**: Babywearing, Gait, Kinematics, Pregnancy, Front Wrap, Back Wrap*

Introduction

To carry babies, many methods and tools are available. In native societies, infants are carried in a close body contact to the mother who provides a constant access to the nutrition for baby during the lactation period and women carry their babies more than 50 % of the daytime till the age of 10 months or longer (Schön and Silvén, 2007). Cross-culturally, five main methods for carrying babies were developed as mothers needed to free their arms to be able to work: front wrap, prevalent in today Euro-American society, using a single piece of cloth or a carrier; back wrap, the most widespread in native societies, using a single piece of cloth or in the hood of parka in Inuit society; side sling, on the mother's hip supported by a piece of cloth; no tools, in arms, do not allow to free completely the mother's arms for work; and cradles, predominant in native North American societies, in whose the baby was laying for most of the day (Aryes, 1973; Singh, 2009).

In the contemporary Euro-American society, babywearing is getting popular among the parents and caregivers as it provides among others a close physical contact with the baby, who is calmer hearing the heartbeat, and stimulations for interaction of the baby and the carrier and their surroundings. Furthermore, babies who are babywear regularly were observed to cry less and to be healthier (López Acuna, Salmerón Ruiz, 2014).

However, changes in the posture and gait of the female carrier were observed in all four previously described types of baby carrying in a babywearing simulation kinematic study using different weights (Singh, 2009). The alterations in gait kinematics reflect the change in one of the two dominant characteristics: energy or safety; and may be associated with increased prevalence of back and foot pain or other clinical complications (Forczek, Staszkiewicz, 2012; Branco et al., 2013). Nevertheless, the number of studies focusing on the effect of babywearing on maternal gait changes is limited as most of the studies about babywearing are focused on the effect of this type of transportation on the baby. Therefore, the aim of this study was to compare the longitudinal maternal gait changes during pregnancy, postpartum period and postpartum during the front wrap and back wrap babywearing condition.

Methods

One pregnant woman was measured longitudinally. She participated at the data collection at the 16 and 38 weeks of gestation (g.w.) and 8 months after delivery. The participant height was 1.70 m and her weight during 1st, 2nd and 3rd data collection was 61.2, 80.41 and 63.6 kg, respectively.

At each data collection, the participant was asked to walk barefoot trough a 7 meters long pathway in a space captured by Simi Motion system. She walked the pathway three times at her preferred speed. The purpose of the first and second trial was to set a natural walking condition, the third trial was used for further analysis.

An 8 markers set was placed on the participant who wore a fitting top and shorts. The retro-reflective markers were placed on the anthropometrical points of right and left side acromiale, iliospinale anterius, tibiale laterale and malleolus lateralis. For the babywearing condition at the last data collection session a front wrap and back wrap were used since the frontal and dorsal babywearing are the predominantly used types (Kolářová, 2013). The baby weight was 8.6 kg.

Following variables were analysed: step width, step length; maximal hip extension; maximal hip flexion; knee joint height, maximal knee extension; maximal knee flexion, trunk left-right motion and trunk anterior-posterior motion.

Results and Discussion

Analysed variables during pregnancy at the 16 g.w., 38 g.w. and 8 months postpartum without baby and 8 months postpartum front and back wrap babywearing condition are shown in Table 1. The most noticeable changes, compared to the 16 g.w., were found during the measurement at the last trimester of pregnancy. Walking alone after the delivery, the pregnancy alterations persisted mainly in maximal knee flexion. During the babywearing condition the most substantial difference, compared to walking alone, were found in decreased maximal lateral trunk angle (during the front wrap) and maximal anterio-posterior trunk angle (during the back wrap).

Table 1. Analysed variables at 1st, 2nd and 3rd data collection session (R: right; L: left).

			8 months pospartum		
	16 g.w.	**38 g.w.**	**Alone**	**Front wrap**	**Back wrap**
max. hip extension R	175.80	176.96	172.68	173.24	171.27
max. hip flexion R	145.07	121.83	151.26	143.92	152.37
max. hip extension L	178.42	178.29	177.13	179.49	178.18
max. hip flexion L	148.80	127.82	147.02	144.10	156.72
max. knee extension R	177.50	177.10	175.97	175.61	173.70
max. knee flexion R	126.96	149.68	133.20	128.43	127.26
max. knee extension L	178.60	179.69	176.50	177.33	177.75
max. knee flexion L	120.90	159.27	131.54	128.99	125.98
max. lateral trunk angle	2.82	3.93	2.61	1.25	2.83
max. anterio-posterior trunk angle	10.93	21.35	11.44	15.71	4.81
max. knee high R	0.45	0.46	0.46	0.48	0.48
max. knee high L	0.47	0.45	0.49	0.49	0.50
step width	0.16	0.18	0.17	0.17	0.17
step length	0.69	0.60	0.64	0.64	0.63

16 gestational weeks

As most of the pregnancy-related changes occur between the 16th to 32th week of pregnancy (Ribeiro, Joao, Sacco, 2013), for purpose of this study, the 16 g.w. simulates the "pre-pregnancy" gait pattern.

38 gestational weeks

In this study, increased hip flexion with the advancing pregnancy was observed. During pregnancy, an increase in hip flexion has been commonly reported also in previous studies (Branco et al., 2014; Hagan, Wong, 2010; Foti et al., 2000). Despite the frequently described knee hyperextension, also a decrease in maximum knee extension and no change of knee range of motion were observed in advanced pregnancy in previous studies (Aguiar et al., 2011; Aguiar et al., 2015; Forczek, Staszkiewicz, 2012; Branco et al., 2012; Ribeiro, Joao, Sacco, 2013; Sawa, et al, 2015). No difference in knee extension was found in current study; however, a noticeable decrease in maximal knee flexion was observed. Additionally, a greater lateral and anterio-posterior shifting of the body during advanced phases of pregnancy was observed in this study confirming the findings of previous studies (Ribeiro, Joao, Sacco, 2013; McCrory et al., 2014). During pregnancy, a decrease in a stride length and an increase in step width have been reported previously (Ribeiro, Joao, Sacco, 2013). This finding was observed also in this study.

Postpartum: Alone

Six months postpartum spatio-temporal and most of the kinematic gait characteristics were reported to get to pre-pregnancy levels (Błaszczyk et al., 2016; Forczek, Staszkiewicz, 2012; Hagan, Wong, 2010). This finding is in accordance with the observation of this study. The pregnancy related alteration persisted in the maximal knee flexion, knee high and the step length in this study. Similar observations were found in a study by Forczek and Staszkiewicz (2012) on 13 pregnant women.

Postpartum: Front wrap

In this study, the most noticeable changes were observed, compared to the postpartum alone condition, in the decrease of maximal lateral trunk motion, increase in maximal anterio-posterior trunk motion and increased maximal hip and knee flexion. Similarly, in the previous babywearing simulation study significant increase in the maximal hip flexion angle and decrease in maximal hip extension angle were found during the front wrap. In that study, no significant changes in lateral or forward trunk angles were found although a not statistically significant tendency to lean forward while carrying a lighter weight simulating the baby was observed. (Singh, 2009)

Postpartum: Back wrap

In this study, increase in maximal knee flexion and maximal knee high and decrease in maximal hip flexion, maximal anterio-posterior trunk motion and step length were observed. In contrast to the results of this study, significant increase in hip flexion angle and forward trunk angle were observed in a previous babywearing simulation study (Singh, 2009) possibly caused by the different weight of the babies.

Conclusions

Results from this study confirm changes in the maternal gait during babywearing. Changes in the gait pattern induced by the front wrap babywearing are similar like the 38 g.w. of pregnancy condition. However, a decrease in the maximal knee flexion and lateral trunk motion and increase in step length were observed during the front wrap compared to the advanced pregnancy. During the back wrap babywearing condition compared to the advanced pregnancy data collection session an increase in maximal knee flexion, maximal knee high and step length and decrease in maximal anterio-posterior trunk motion, step width and maximal hip flexion were observed. Future studies on a greater number of participants are needed to compare the impact of frontal and back wrap babywearing on maternal gait.

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THE INFLUENCE OF TRAINING ON AUTONOMIC NERVOUS SYSTEM CARDIAC MODULATION

Hopovac Almin, Klarić Zdenko
Faculty of kinesiology at the University of Zagreb

Abstract

Heart rate variability (HRV) is a degree of fluctuation in the interval length between successive heart beats. The cardiovascular system is mostly controlled by autonomic regulation through the activity of sympathetic and parasympathetic pathways of the autonomic nervous system. Analysis of HRV permits insight in this control mechanism. Research has shown that HRV is a very accurate, reliable, noninvasive and easy to apply method for diagnostics of the autonomic nervous system state. The literature search was carried out in the Web of science (WOS), Medline and Ebsco bibliographic bases. Studies which examines the influence of different training types on autonomic nervous system cardiac modulation in athletes. The key words used in the literature search are: „Heart rate variability" AND „training" AND „effects" AND „athletes". The search given 146 papers. Fifteen studies were included in this review. The results of the study can be considered in four aspects: The aspect of acute effects of training on HRV indices,the aspect of chronic effects of training on HRV indices, the aspect of the influence high and low intensity training on HRV indices ,and the aspect of influence of overload training on HRV indices. Acute effects of low and high intensity training are leading to a suppression in parasympathetic activity, and the time for parasympathetic reactivation depends on training intensity. Additionally, the chronic effects after training interventions stay the same like in the initial state, or have a rebound after recovery from the training intervention. When considering overtraining and overreaching contradictory in studies were found. Some studies showed parasympathetic hyperactivity, and some studies a decreased parasympathetic activity, rather vagal related HRV indices.

Key words: *HRV, ANS, sympathetic activity, parasympathetic, training, performance, training load, overtraining, athletes*

Introduction

Heart rate variability (HRV) is a degree of fluctuation in the interval length between successive heart beats. The cardiovascular system is mostly controlled by autonomic regulation through the activity of sympathetic and parasympathetic pathways of the autonomic nervous system. Analysis of HRV permits insight in this control mechanism. Research has shown that HRV is a very accurate, reliable (Nakamura et al., 2016), noninvasive and easy to apply method for diagnostics of the autonomic nervous system state (Task Force, 1996). The variations in heart rate may be evaluated by a number of methods. The time domain (RR, NN, SDNN; rMSSD)[8], frequency domain (HF, LF, LF/HF)[9] and non linear methods standardized by TaskForce are used to determine HRV indices. It has been reported that increase and decrease in HRV indices are associated with positive /(M. Buchheit, Simpson, Al Haddad, Bourdon, & Mendez-Villanueva, 2012), (Lee, Wood, & Welsch, 2003), (Mourot, Bouhaddi, Tordi, Rouillon, & Regnard, 2004), (Vesterinen et al., 2015), (Atlaoui et al., 2007)/ and negative (Hynynen, Uusitalo, Konttinen, & Rusko, 2006) (Hynynen, Uusitalo, Konttinen, & Rusko, 2008) (Uusitalo, Uusitalo, & Rusko, 2000) training adaptations. The results of the mentioned findings, the different methods of measuring HRV makes it difficult to conclude how HRV indices responses to different training types, training load and which method is desirable for measuring and monitoring ANS modulation of the heart (HRV). The purpose of this short review is to systematize and examine the influence of different training types, training load on HRV indices, or the ANS activity in athletes. The study examines different training types, such as high and low training intervention, aerobic and anaerobic training types, overload training types and resistance training types and they're influence on ANS cardiac modulation.

Methods

The literature search was carried out in the Web of science (WOS), Medline and Ebsco bibliographic bases. We only included studies which examines the influence of different training types on autonomic nervous system cardiac modulation in athletes. We used the key words „Heart rate variability" AND „training" AND „effects" AND „athletes". The search given 146 papers. We included 15 studies in this review. Study inclusion criteria: the study includes a clear training protocol, the study includes training effects on HRV indices, the study includes athletes as subjects.

In the table below included studies in this paper are presented (Table 1). The table contents the authors of the studies, the aim, intervention,subjects, methods and the results od each study. We made conclusions based on the results of the included studies in this review.

[8] Time domain Heart rate variability indices
[9] Frequency domain Heart rate indices

Table 1. Systematization of included studies in the review

Author	Purpose	Intervention	Subjects	Measuring method and variables	Conclusion
Yan Le Meur (2014) Evidence of Parasympathetic Hyperactivity in Functionally Overreached Athletes (Le Meur et al., 2013)	Analysing HRV to detect alterations in autonomic function that may be associated with functional overreaching in endurance athletes.	7 weeks: 3 weeks usual triathlon training, 1week low intensity < 50% TL, 3week +40% TL	24 (21) highliy trained triathlon athletes	Supine 7 min, Standing 7 min Running performance TL-training load, HR, HRV, HR7davg, HRV7_{davg}, Ln HF, Ln LF+HF	Autonomic modulations toward a parasympathetic predominance in the functionally overreached endurance athlete
Bellenger (2015) Contextualizing Parasympathetic Hyperactivity in Functionally Overreached Athletes With Perceptions of Training Tolerance (Bellenger et al., 2016)	Contextualizing changes in HRV with subjective measures of training tolerance	Running: 1 week LT (65-75% Hrmax 30min/d) , 2 weeks HT (66min/d 36% above 88% H_{max}) 10 days tapering	22 male triathletes	Resting HRV Supine and standin position 7-d average values Performance (5 km running time) LnRMSSD	Vagally mediated HRV during standing increased in response to functional overreaching (potential parasympathetic hyperactivity) and also to improvements in performance.
Da Silva (2013) Longitudinal changes in cardiac autonomic function and aerobic fitness indices in endurance runners: A case study with a high-level team (Da Silva, Verri, Nakamura, & Machado, 2014)	Determine the effects of preparatory phase training on aerobic parameters, resting HRV and 5-km performance of high-level endurance runners and the relationship between the % change of resting HRV with the % change of aerobic parameters and 5-km performance.	7 weeks of preparatory phase: 6 days per week running (4-5 continues at 65-70% Vo2_{max}, 1 interval training), Resistance exercise 2xweek Pilates 1x week	6 male endurance runners	Resting HRV 10 min in the sitting position (5 min recording) Incremental running test (vo2max) 5 km running performance, rMSSD, Rrmean, LF, HF, SD1, SD2, RPE	Decrease in HF and increase in LF band. Change in the rMSSD and SD1 were highly correlated with variation in 5-km performance. Changes in the velocity associated with VO2_{max} and vagally mediated HRV were highly associated with 5-km performance
Plews, Laursen et al (2012) Heart rate variability in elite triathletes, is variation in variability the key to effective training? (Plews, Laursen, Kilding, & Buchheit, 2014)	Monitoring daily HRV in two elite triathletes over a 77-day period	Swimming, cycling, running training 23 ± 2 h per week, over a 77-day competitive period.	2 elite triathletes	Measuring daily morning resting HRV Supine position 6 min, recording 5 min	Decreasing trend in the 7-day rolling HRV average may be a useful marker to indicate the development of non functionally over-reached (NFOR) endurance athletes. Decrease in the day-to-day variability HRV values and the transfer from a ''saturated'' to a ''linear'' HRV profile may be further indicators of NFOR.
Plews et al. (2014) Heart-Rate Variability and Training-Intensity Distribution in Elite Rowers (Plews, Laursen, Kilding, & Buchheit, 2012)	Examine the relationship between heart rate variability and training intensity distribution in during the 26-week elite rowers build-up	training intensity distribution in 9 elite rowers during the 26-week build-up to the 2012 Olympic Games	9 elite heavyweight rowers	Suppine resting HRV in teh morning 6min-5min of the 6 min recording HRV, RMSSD	Training phases with in creased time spent at high-intensity suppress parasympathetic activity, whilst low-intensity training preserves and increases it.
Stanley et al. (2013) Cardiac Parasympathetic Reactivation Following Exercise: Implications for Training Prescription (Stanley, Peake, & Buchheit, 2013)	highlight the value of assessing cardiac parasympathetic reactivation in the hours following a single bout of exercise to derive individual recommendations for training (at least for cardiovascular outcomes).	Meta - analysis	8 studies	Study inclusion criteria: cardiac parasympathetic recoveri after a single bout of excersise, HRV measures taken form the end of excersise up until 72 h post exc 8 studies.	The influence of exercise duration on the time course of cardiac parasympathetic recovery is unclear. However, exercise duration is unlikely to be the greatest determinant of cardiac parasympathetic recovery
Bucheit et al. (2008) Exercise-induced plasma volume expansion and post-exercise parasympathetic reactivation (Martin Buchheit, Laursen, Al Haddad, & Ahmaidi, 2009)	Investigate the effect of exercise-induced plasma volume expansion on post-exercise parasympathetic reactivation.	2 continuous 6-min submaximal running tests (CT1 and CT2) to assess parasympathetic reactivation, and a short supramaximal intermittent exercise test aimed at inducing plasma volume expansion	11 moderately trained males.	Post exercise. Sitting position, 5 min recording in the 10 min recovery time. HR, HRR, HRV and plasma volume (hemoglobin and hematocrit), IFT: VO2_{max} , V_{ift}	Significant increases in all vagal-related indices 2 days after the supramaximal exercise bout, whereas the rate of HRR was not affected.
Seiler et al. (2007) Autonomic Recovery after Exercise in Trained Athletes: Intensity and Duration Effects (Seiler, Haugen, & Kuffel, 2007)	To investigate the effects of training intensity and duration, through a range representative of training in endurance athletes, on acute recovery of autonomic nervous system (ANS) balance after exercise.	HT performed four intensity-controlled training sessions: 60 min and 120 min below first ventilatory threshold (VT1); 60 min with 30 min between VT1 and VT2 (threshold); and 60 min above VT2. T also completed the interval session	9 highly trained (HT) male runners and 8 trained (T) male subjects	Supine 5 min recording. Pre and post exc. After each training session, 5-min supine RR interval measurements were made beginning at 5, 15, 30, 60, 90, 120, 180, and 240 min after exercise. VO2_{max}, VT1, VT2 RPE, HRV	Parasympathetic reactivation after exercise below VT1 was extremely rapid. In contrast, when exercise was performed at intensity above the (VT1), ANS recovery was significantly delayed. VT1 seems to be a clear threshold of ANS perturbation.
Kaikonen et al. (2007) Post-exercise heart rate variability of endurance athletes after different high-intensity exercise interventions (Kaikkonen, Rusko, & Martinmäki, 2008)	To clarify HRV dynamics, especially vagal reactivation, during the first minutes of recovery and during the slow recovery after high-intensity exercise interventions.	Two interval exercise interventions with 2-min recovery intervals and two continuous exercise interventions in a random order, one intervention per week	8 national-level, endurance-trained males	R R intervals were recorded during and after excersise (5-30 min) Vo2_{max}, vVo2_{max}, RCT, LF, HF, TP	We found no recovery in HFP, but a significant recovery in LFP and TP during the first 5 min after the interventions. We also found some differences in HFP recovery between the different

					intervent ions even though there were no differences in HFP during exercise. The differences in HRV recovery between the interventions became more evident during the slow recovery phase
Edmonds et al. (2013) Effect of a Training Week on Heart Rate Variability in Elite Youth Rugby League Players (Edmonds, Sinclair, & Leicht, 2013)	The aim of this study was to examine the infl uence of weekly training including a competitive game on heart rate (HR) variability (HRV).	Training week including game day in elite youth rugby players	9 youth national league rugby players.	10 min supine and 8 min standing (5 min recording). Pre 2, game day, post 1, post 2 and post 4 days. Time domain HRV Frequency domain HRV Non-linear HRV indices.	During a normal week of training including a competitive game, participants exhibited a shift in cardiac autonomic balance towards lower HRV on Game Day, reduced HRV and predominant sympathetic modulations for 1–2 days post game, and a reduced supine-tostanding HRV response for up to 4 days after the game
Baumert et al. (2006) Changes in heart rate variability of athletes during a training camp (Baumert, Brechtel, Lock, & Voss, 2006)	We determined whether HRV analysis could be used as a diagnostic tool to monitor overload training and to detect/prevent overtraining syndrome.	2 week Training camp. The daily training program included a stepwise increasing cycling test and additional running of 40 min and cycling of 80 min	10 healthy experienced athletes (five males and five females from track and field or triathlon)	30 min. in supine position Mean NN, sdNN, rmssd, LF, HF, LFn, VLF	The study determined a clear sympathetic predominance during the training. The increased training load during the training camp suppressed the vagal related HRV indices. HRV analysis showed significant changes only for meanNN and rmssd. During the training camp, both parameters were lower and largely returned to normal values after recovery period.
Merati et al (2014) Autonomic modulations of heart rate variability and performances in short-distance elite swimmers (Merati et al., 2015)	evaluate how autonomic modulations of heart rate (HR) variability (V) correlate with performances of short- (<1 min) and very short (<30 s) duration in elite athletes	crawl swimming in short (100-m) and very short (50-m) distances	13 male swimmers, national-level crawl specialists in short (100-m) and very short (50-m) distances	Hrv recorded during 15 min supine rest after wake up, before training session, after training. Heart rate variability (HRV) vagal and sympatho/vagal indices were calculated in time, frequency	Vagal indices were highest in the morning - positively correlated with very short distance times. Sympatho/vagal indices were highest after training - negatively correlated with
				and complexity domains.	short-distance times. Strong cardiac vagal control has no effect on short performances and is even detrimental to very short perf, and that the capacity to powerfully increase the sympathetic tone during exercise may improve short, but not very short perf.
Buchheit et al (2007) Parasympathetic reactivation after repeated sprint exercise (M. Buchheit, Laursen, & Ahmaidi, 2007)	examine the effects of muscular power engagement, anaerobic participation, aerobic power level, and energy expenditure on postexercise parasympathetic reactivation	1) 18 maximal all-out 15m sprints with 17 s of passive recovery (RS), 2) a moderate isocaloric continuous exercise session (MC) at a level of mean oxygen uptake similar to that of the RS trial 3) a high-intensity intermittent exercise session (HI) conducted at a level of anaerobic energy expenditure similar to that of the RS trial	Fifteen moderately trained athletes performed	Parasympathetic reactivation was evaluated through 1) immediate postexercise HR recovery, 2) RMSSD30s and 3) HR variability vagal-related indexes calculated for the last 5-min stationary period of recovery HRR_{60s}, T_{30}, HRR, HR_{amp}, $SDNN_{5–10min}$, $pNN50_{5–10min}$, $RMSSD_{5–10min}$, $lnHF_{5–10min}$ $HFnu_{5–10min}$, $HR_{5–10min}$, $RMSSD_{30s}$	Only anaerobic contribution was related to HR trial-derived indexes. Parasympathetic reactivation is highly impaired after RS exercise and appears to be mainly related to anaerobic process participation.
Sandercock et al (2005) Effects of Exercise on Heart Rate Variability: Inferences from Meta-Analysis (Sandercock, Bromley, & Brodie, 2005)	Determine the effects of exercise training on heart rate and measures of HRV associated with vagal cardiac modulation and to quantify the relationship between changes in these measures.	Meta-analysis	A meta-analysis of 13 studies	Meta-analysis	Exercise training results in significant increases in RR interval and HF power. These changes are influenced by study population age. The smaller effect size for HF and weak relationship between HF and RR
Chen et al (2011) Parasympathetic Nervous Activity Mirrors Recovery Status in Weightlifting Performance After Training (Chen et al., 2011)	The aim of the study was to detect whether HRV and parasympathetic power can reflect recovery status after weightlifting training.	2 h weightlifting training: Four types of exercises were performed: back squat, seated shoulder press,dead lift, and front squat.	7 weight lifters with .6-year training history of national- or international-level competitions.	HRV-seated position-5min (HF, Lfnu, VLF) and weightlifting performance were performed before training, and 3, 24, 48, and 72 hours during recovery.	Evidence that parasympathetic power mirrors recovery status in weightlifting performance after training. Sympathetic activity immediately after training increased an parasympathetic activity suppressed. Returned to baseline by 72 hours.

Results and discusion

The results of this study can be considered from four different aspects:

- the aspect of acute effects of training on HRV indices
- the aspect of chronic effects of training on HRV indices
- the aspect of the influence high and low intensity training on HRV indices
- the aspect of influence of overload training[10] on HRV indices.

When considering acute effects of training, studies demonstrate that during training interventions comes to a parasympathetic withdraw which is leading to a decrease in vagal related HRV indices. The recovery of heart rate variability after training is measured by parasympathetic reactivation and returning the sympathetic and parasympathetic activity to a harmonic state. Recording to the analyzed studies we concluded that the promptness of the parasympathetic reactivation largely depends on the intensity of training interventions. In other words, when training interventions are performed at low intensities (aerobic training) the recovery is fast, recording to some studies /(Stanley et al., 2013), (Seiler et al., 2007), (Kaikkonen et al., 2008)/ already after 30 min, and to complete recovery and a rebound in vagal related HRV indices after 24 hours. On the other hand, after high intensity training (anaerobic training) like weightlifting (Chen et al., 2011), sprinting (M. Buchheit et al., 2007), high intensity interval training (Sandercock et al., 2005), parasympathetic reactivation is suppressed, recording to some studies even over 90 min, and 48 hours to fully recover and return or rebound to the initial state. Studies demonstrated that the chronic effects of aerobic training (Plews et al., 2014), training below the aerobic threshold leading to a increase in parasympathetic activity, rather a better autonomic balance and parasympathetic reactivation. The study by Da Silva et al., 2014 also showed that VO2max and v VO2max are highly correlated with vagal related HRV indices, rather parasympathetic activity. After high intensity training interventions according to the above-mentioned research the chronic effects on vagal related HRV indices are unchanged, or are slightly increased, rather after recovery vagal related indices returns back to initial state or are slightly rebounded /(Le Meur et al., 2013), (Plews et al., 2012)/. When considering the exposure of athletes to high training loads (overtraining), the effects on HRV indices, according to this study, are variable. Generally, training interventions at high training load are leading to an inhibition of the parasympathetic activity, where vagal related HRV indices are decreased, while sympathetic activity

[10] Overload training – training interventions performed at very high training load almost leadin to overtraining, or functional overeaching. For example, training interventions performed at +40% of usual training load (Table 1, Yan Le Meur et al, 2014).

is increased(Baumert et al., 2006). There are researches which cite that long-term training below the anaerobic threshold at high training load leads to a increase in parasympathetic activity(Plews et al., 2014).

Researches showed that in the phases of overreaching, performance decreasement and bad mood, parasympathetic activity, rather vagal related HRV indices are decreased(Plews et al., 2012)(Bosquet, Merkari, Arvisais, & Aubert, 2008), while sympathetic activity is increased. Other studies (Bellenger et al., 2016)(Le Meur et al., 2013) showed opposite results.

Conclusion

In the end, this study leads to a conclusion that acute effects of low and high intensity training are leading to a suppression in parasympathetic activity, and that the time for parasympathetic reactivation depends on training intensity. Additionally, the chronic effects after training interventions stay the same like in the initial state, or have a rebound after recovery from the training intervention.

When considering overtraining and overreaching it is difficult to conclude about the effects on HRV indices because of the contradictory of studies. Plews et al., 2012 showed that overreached athletes have decreased vagal related HRV indices, while Le Meur et al., 2013 showed increased vagal related HRV indices in functionally overreached athletes, rather parasympathetic hyperactivity. The results of Plews et al can be explained by the results of Baumert et al., 2006 and Bosquet et al., 2008 who showed that an increase or decrees in vagal related HRV indices depends on training distribution in low or high intensity zones. The mentioned results can not explain the results of Hedelin, Kentt, Wiklund, Bjerle, & Henriksson-Larson, 2000 and Le Meur et al., 2013 which demonstrated an increase in vagal related HRV indices, or parasympathetic hyperactivity, despite training in high intensity training zones. The reason for the concurrency of some research results may be required in non-standardized measurement procedures, such as different positions (supine, standing, sitting...), or different time of measuring HRV, or taking seven day mean values of HRV as variables. A development of standardized measuring methods is required, and also further research so that more concrete conclusions could be made.

HRV is undoubtedly one of the best noninvasive methods and indicators of the autonomic nervous system state of athletes, and represents a very good training monitoring tool to manage training, stress and recovery in athletes.

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HOW TO MEASURE PHYSICAL DEMANDS OF WORK WITH PERSONAL COMPUTER USING THERMOGRAPHY – NOVEL APPROACHES

Horáček Jan, Novotný Jan

Department of Kinesiology, Faculty of Sport Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: In medicine and affiliate scientific disciplines we have gotten used to many diagnostic tools measuring or displaying mostly structural changes (X-ray, ultrasound, CT etc.). It´s pity, that even when we have a tool displaying functional changes, thermography, we are still after some decades not able to use it properly. Despite the fact personal computers are used to "make work easier" for about thirty years, there is still not much scientific work done on this topic. Especially not on the field of thermography where we could use this not really young method to enhance our knowledge of how hard the work with personal computer really is and what are dynamics of this workload. This paper presents a comparison between the methods used over the last twenty years for studying the thermal changes in hands while the subject is working on a personal computer and Horacek's newly developed method. In doing so, it sets up the best-known methodology for the next few years in which anticipated "bigger research" should be done. All of this is done in a real environment where office workers are doing their job - at their workplace. *Methods:* In this study, ten office workers were studied using a thermographic camera, and then the results of two methodologies were compared. Another two methodologies already used to describe thermal changes in hands were also considered. *Results:* The results showed us similarities at 84% with the already used methodology developed by Gold, but 75% higher sensitivity with a mean difference of 1.6 ℃. *Conclusions:* It was found that Horacek's methodology, when compared to Gold's methodology, has not only comparable specificity but even higher sensitivity. This method is also easier and faster. Thus, taking into account the lack of current scientific knowledge, it is probably appropriate method for observing thermal changes in hands. These results encourage us to carry on next researches which are desperately needed.

***Key words**: hand, methods, thermography, workload*

Introduction

Despite the fact that employees in different sectors of the economy have been using personal computers (together with a mouse and keyboard) for about thirty years, and despite the fact that there are dozens of scientific papers describing many negative aspects of this work, there has still been very little research, especially using thermography, on office workers' hands. Even though, since the 1990s, many papers has been written about "a promising non-invasive method that needs more research"(Sharma, Smith, Hazleman, & Jenner, 1997), still, unlike X-ray or sonography, there has been no significant research or at least some guideline as to how to go about it and what to expect/look for. After all, this poor status is only proven by Ring´s words, that thermography "is often misunderstood, or not been used due to lack of knowledge of thermal physiology and the relationship between temperature and disease".(Ring & Ammer, 2006)

To provide a wider background for future scientific studies into the working hygiene of office workers, extensive research was conducted in finding the most appropriate way of monitoring thermal changes in hands over a day. This study was designed to find and define a methodology that would be easy, quick and cheap (with all these conditions basically meaning the same these days). Also, of course, and as a priority, there were efforts to find a method that would be at least as reliable as the methodologies used so far. Another goal was to find a methodology that would be as sensitive as possible to the potential changes and assumed work-induced pathological changes already described by Gold (Gold, Cherniack, Hanlon, Dennerlein, & Dropkin, 2009). It would be wonderful to be able to write that since the 1990s, when thermography was first used to study thermal changes in hands, many protocols on how to do it have already been published. Unfortunately, this is not the case. Basically, only two or three ways how to do it have been published so far. None of these fulfilled the expectations for quickness, simplicity and reliability. This has led to the invention of a new procedure and subsequent comparison.

Our opinion that only small scientific effort was focused to this topic was confirmed also by Seixas and Rodrigues (2016). In his review he listed all five studies monitoring hand temperatures during computer work using thermal imaging since its inception also found by us.

These papers were published by:

Sharma (Sharma, Smith, Hazleman, & Jenner, 1997)
Gold (Gold, Cherniack, & Buchholz, 2004)
Gold (Gold, Cherniack, Hanlon, Dennerlein & Dropkin, 2009)
Gold (Gold, Cherniack, Hanlon, & Soller, 2010)
Reste (Reste, Zvagule, Kurjane, Martinsone, Martinsone, Seile & Vanadzins, 2015)

After work undertaken by our group to try to find more studies, we have to say that there is probably no other on this subject. These five papers basically provide just three methodologies for processing thermal data obtained by thermal cameras. All of them use mean temperatures in specific areas on the dorsal side of the hand/hands. All of them also describe why their way is the best, yet none of them provide a comparison with the others or with some other “not the best” methods. All the methods and their studied areas are shown in Fig. 1.

Sharma (as shown in Fig. 1) used “over 200 to 350 pixels on the second, third and fourth proximal phalanges of both hands, avoiding large muscle masses that might interfere with the readings.” ((Sharma, Smith, Hazleman, & Jenner, 1997)

Gold used the same method in all her quoted papers, also shown in Fig. 1. She used the mean temperature of the metacarpal region of the dorsal right hand. Only once (Gold, Cherniack, Hanlon, & Soller, 2010) she did not specifically say that she was measuring only the right hand, but as she used the singular form, it can be assumed that she used the same method as in her other studies (Gold et al., 2004, 2009). She defined this area as the area bounded by the heads of the ulna and radius and the metacarpal joints. She added that according to Stansberry (Stansberry, Peppard, Babyak, Popp, McNitt & Vinik, 1999), the hairy skin of the metacarpal region is the most reliable location for detecting vascular response and abnormality in the hand, unlike the glabrous skin of the fingers.

In her work, *Reste* used her own methodology based on the mean temperature of “the dorsal surface of the right wrist at the level of the metacarpals and the proximal half of the lateral surface of the right forearm (projection site of the wrist extensor muscle group).“ (Reste, Zvagule, Kurjane, Martinsone, Martinsone, Seile & Vanadzins, 2015) As can be seen in her own figures, she used some kind of ellipse, placed with no more specific description in the middle of the metacarpal area (as shown in Fig. 1). Despite this, it was assumed to be very like Gold’s methodology, if not identical.

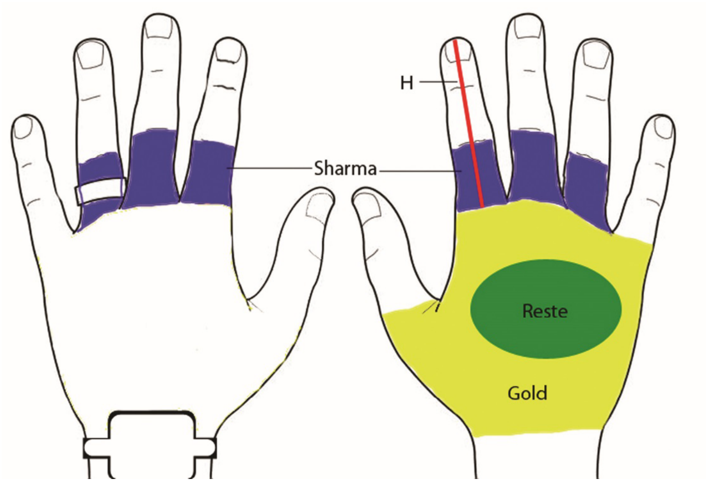

Figure 1. Areas of hands monitored by different authors

As can be seen in Fig. 1, of all the methodologies used so far, only Sharma's methodology was excluded - not only for not being sufficiently described, but also for being very troublesome to process using thermal imaging software unless some type of automatic locator was also used. Also, the difficulty with wedding rings was also considered. These are usually worn on the left or right ring finger (proximal phalanx of finger IV). If researchers wish to compare both hands, the data would be either difficult to process without misinterpretation or would not represent the real environment if all married people had to be asked to take the ring off for measuring. People wear wedding rings all the time, some of them even while sleeping, so why should they have to take it off while being measured if the research is concerned about their hands in real life?

Also, Reste's method was excluded for not being sufficiently specified and for probably being very similar, if not the same, as Gold's method.

Methods

Brand new methodology ("H method") has been designed by our group for hopefully upcoming studies of working hygiene while using PCs. It was considered that if finger temperature is less stable than that of the metacarpal area, as Gold stated (Gold, 2002), and if fingers are better for avoiding large muscle masses that might interfere with the readings (Sharma, Smith, Hazleman, & Jenner, 1997), then the goal could be to compare it with the already mentioned "most reliable metacarpal area" ((Stansberry, Peppard, Babyak, Popp, McNitt & Vinik, 1999). Under these conditions, the focus was the mean temperature of the line going up the middle of the index finger of the right hand starting on the tip of the finger and ending on the base of the proximal phalanx (also shown in Fig. 1). The index finger was chosen for its crucial involvement when using the computer mouse. As the index fingers are sometimes not straight, the line was bent if necessary to keep the line in the middle of the finger. All this on the dorsal side of the hand.

As can be seen from the arguments above, there were only two methodologies to compare. Gold's one and our new methodology. As far as Gold's method is concerned, it has proven capable of detecting pathologies in hands many times (Gold et al., 2004, 2009) and was used as the standard for comparison with our method. Yet the dissimilarity between the two methods does not indicate lower reliability of our method, rather just a different capability for recording hand pathologies. This capability could also be higher.

Measuring

The subjects of the study were three information technology (IT) specialists who do the majority of their work on personal computers (PCs), and seven state clerks working almost strictly on PCs. All participants provided written informed consent. The gender distribution was four men and six women. The mean age of the participants at the time of measuring was 32, with a standard deviation of 9.8 years. In the question of handedness, two said they were lefthanded and the other eight righthanded. Only one of the two lefthanded subjects, however, used a computer mouse with his dominant hand. The rest of them used their right hand. Only one subject stated that they had some difficulties with their hands in the last few days, and also on the day of measuring. Seven subjects stated that they felt some difficulties in the last few days, but not on the day of measuring, and two subjects did not state any problems with their hands they thought were due to working with a PC. One of the subjects stated an unspecified tremor of the hands, one had second-degree burns to the hand and forearm in childhood, and one had so-far non-diagnosed Reynaud syndrome. As can be seen, these subjects were on the one hand similar enough to participate as "average office workers", while on the other hand they were different enough to also be controls for each another. As far as the object of this research is concerned, it was not to compare these people but the methodologies – these subjects were used without special concerns about their diversity. On the contrary, we welcomed it.

To comply with the aim of measuring in a real environment, the measuring itself took place from the beginning of the shift and ended with the lunch break.

It was composed of initial measuring followed by measuring every half an hour – as accurately as possible as permitted by their working tasks. With respect to the different times of arrival of the employees at work and when they left for lunch, 67 measurements were performed approximately every half an hour, but not at the same time for all the participants. For the statistical processing, the obtained data were put into tables with strict intervals of thirty minutes. However, in the graphs the real timing of the measurements was used to show the dynamics of skin temperatures without possible misrepresentations. On average, all the measurements were done 1.4 minutes earlier with a standard deviation of 6.6 minutes. In the case of missing data due to the absence of a worker or a technical matter, these data were calculated as the arithmetic mean of the surrounding data. This was done in eight cases. The mean time of measuring was 177.2 minutes (2 hours and 57 minutes), with a standard deviation of 16.6 minutes. In total, this meant five to eight measurements for each subject.

As the measuring was done in two different working places in two days, the conditions were also slightly different, but consistent over a whole forenoon. The three IT specialists were measured in an ambient temperature of 23.9 ℃ and a relative humidity of 48.6%, while the state clerks had an ambient temperature of 24 ℃ and a relative humidity of 53%. Both days were typical, hot summer days in June and July, which excluded the need for thermal adaptation of the hand to the warm indoor temperature. However, this thermal adaptation was performed anyway, because before every first measurement there was a break of at least 15 minutes to introduce the research and the researcher to the employee/test subject.

All thermograms were taken using a FLIR P660 thermal camera with emissivity set to 0.98. The images taken were then assessed in ThermaCAM™ Researcher Pro 2.10, FLIR. In Fig. 2 the image of the hands dorsal of participant 2 assessed in ThermaCAM™ Researcher Pro 2.10, FLIR can be seen with “H lines” and Gold method areas marked on both hands. This this particular image also shows possible troublesome areas of the wedding ring and wrist watch. The slightly bent line due to the index fingers not being straight can also be seen. All the data obtained were afterward processed in Microsoft® Excel® 2016, MS Office 365 ProPlus. For some statistical calculations STATISTICA 12, Dell Software was used.

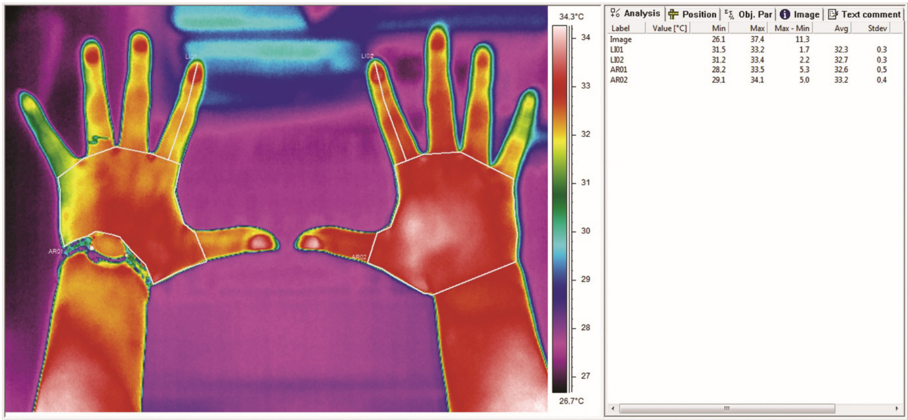

Figure 2. One of the thermographs of participant 2 assessed in ThermaCAM™ Researcher Pro 2.10, FLIR

Mathematical processing

To compare the data obtained, we used the Wilcoxon pair test for each person, comparing data from both methodologies.

To mathematically prove the similarity between our and Gold's methods, several tests were done.

To prove that even with different outcomes – as expected – the data from H method have the same tendency (if the hands are getting colder/warmer, they are getting colder/warmer with both methodologies in the same way, and not the opposite), the value of the earlier temperature (T1) was subtracted from the later one (T2) and the results divided with Gold's each one by one.

The formula used was $X=(T_{2H}-T_{1H})*(T_{2G}-T_{1G})$. If X was positive, the thermal tendencies measured by H were the same as those measured by Gold. Negative values pointed to different directions. An X equal to 0 referred to a steady temperature in at least one of both methodologies. In these cases, the tendency was defined manually after considering the graphs.

After calculating the direction of the thermal changes, and thus the specificity according to Gold's method, it was also convenient to mathematically prove that the data provided by our method have a higher amplitude and so are easier to read, and it is easier to detect even small differences. This was achieved by comparing the absolute values of the thermal changes between all the measurements and comparing the methodologies. Using the formula $Y=|T_{2H}-T_{1H}|-|T_{2G}-T_{1G}|$. Again, if Y was positive, H methodology had a larger difference than Gold's one, while if negative, the difference in Δ was smaller and, if equal to 0, both methodologies were the same.

Results and Discussion

Our methodology for assessing thermal data taken from hands during office work with a PC without using special software for capturing specific areas of the hands was found to be easier and much faster than Gold's one.
The Wilcoxon test as shown in Table 1 showed significant differences in seven out of ten cases, which points to significant differences between these two approaches to the issue.

Table 1. Wilcoxon test p values for both methodologies for all participants

Participant	*p* value
1	0,028
2	0,021
3	0,006
4	0,005
5	0,167
6	0,033
7	0,006
8	0,003
9	0,593
10	0,641

The first thing that can be noticed after putting the data into tables and graphs is that the curves - as can be seen in Fig. 3 - are very similar with only slight differences. From this optical evaluation, we can say that they are at least alike. Using a mathematical proof we received the following results.

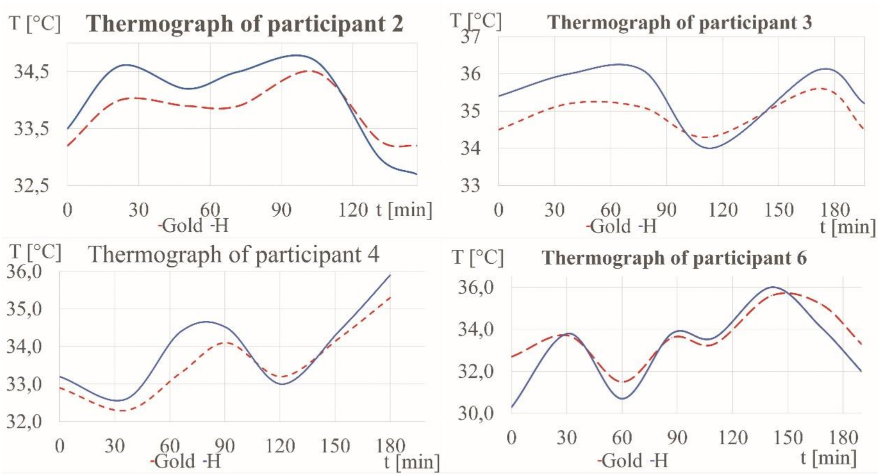

Figure 3. Selected thermal graphs of participants 2, 3, 4 and 6

The tendencies of the curves were the same as Gold's in 50 out of 65 cases. Negative numbers and therefore different directions came out in 10 cases. In five cases, X was equal to 0, but in all five cases the tendency was manually defined to be similar. It gave 55 out of 65 mathematically-proven time periods in which our thermal curves were not the same, but with the same tendencies as Gold's ones. In other words, 84% similarity.

Regarding different amplitudes of thermal curves, positive Y and thus a higher difference of Δ appeared in 49 out of 65 cases. In 13 cases, Gold's method had better values. In 3 cases, they were equal. This points to higher sensitivity in 75.4% of cases.

Another way of doing this was to compare the minimal and maximal measured temperatures and their variation range. The sum of variation ranges in Gold's method was only 29.4 ℃, while the sum of the mean temperatures in our method was 44.9 ℃. The mean variation range in Gold's method was 2.81 ℃, and in our method 4.49 ℃, as can be seen in Table 2.

Table 2. Table of minimal and maximal measured temperatures for all participants, and their variation range

Participant	Methodology	min.[℃]	max. [℃]	Variation range [℃]
1	Gold	28	31.4	3.4
	H	28.1	31.8	3.7
2	Gold	33.2	34.5	1.3
	H	32.7	34.7	2
3	Gold	34.3	35.6	1.3
	H	34	36.1	2.1
4	Gold	32.3	35.3	3
	H	32.6	35.9	3.3
5	Gold	28.5	34.6	6.1
	H	24.5	34.8	10.3
6	Gold	31.5	35.6	4.1
	H	30.3	36	5.7
7	Gold	31.8	33.7	1.9
	H	29.6	33.1	3.5
8	Gold	32.3	34.4	2.1
	H	32.8	35.1	2.3
9	Gold	34.1	35	0.9
	H	31.8	35.4	3.6
10	Gold	29.4	33.4	4
	H	26.1	34.5	8.4
			SUM Gold	29.4
			SUM H	44.9
			MEAN Gold	2.81
			MEAN H	4.49

Looking at our method alone, there are some risks to be seen. In this comparison study, nothing is written about specificity to record any pathophysiological processes in the hands while working on a PC. Sharma, Gold, and others, already proved the dependence of pathology and hand temperature in some ways. What we are saying is that our methodology compared with Gold's is easier (faster, cheaper etc.) and brings more detailed knowledge of what is happening in the hands during computer work shown through more significant thermal changes.

Studying thermal graphs obtained under identical conditions on different points of the hands gave thermal curves which have in 84% the same tendencies (shapes) but higher amplitudes in 75.4%. These amplitudes are higher by about 1.61 ℃, which is not negligible and in the future could help to find differences even in cases in which Gold's method would not detect them. A difference of 1.61 ℃ may look small, but in the field of measuring hand temperatures it is more than the thermal change experienced by some people during the whole day – as can be seen in Table 2.

Through the significant similarities between the data obtained using both methodologies, this study confirms the capability of our method to record changes going on in the hands during computer work. Dissimilarities could on the other hand point to not worse, but better, outcomes which are to be seen at least in the higher variation ranges.

Conclusion

We compared new designed H method for evaluating hand temperature changes with other already available methods. We also mathematically compared this method with method of Gold.

We found it comparable with Gold´s method in 55 out of 65 cases but in 49 out of 65 cases more sensitive.

In all cases we found our method to be easier and faster to perform.

Therefore, for longer-term measuring, thermal imaging of the index finger presented by our group should be preferred over the imaging of the whole dorsal part of the hand. It should be agreed with other authors, that fingers – without large muscle masses – are more prone to thermal changes. Unlike them, this characteristic should be appreciated more than feared but without doubt need further research.

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Corresponding author:
Jan HORACEK,
Department of Kinesiology, Faculty of Sport Studies,
Masaryk University, Kamenice 5, Brno- Bohunice 625 00, Czech Republic.
Tel: +420 728 867 079, e-mail: horacek.ja@seznam.cz

SENSORIMOTOR SKILLS AND SPECIFIC TIMING IN ADOLESCENT POPULATION 6–18 YEARS

Hromčík Adam, Zvonař Martin
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

Following the number of studies dealing with the timing of the movement, focusing on the adult population and the population with cerebellar symptoms such as a Parkinson disease or essential tremor, (Bareš, 2014), we try to look at the timing from other point of view. After effort to explain the causes of slowness and their relationship with age or stage of a disease, the present study attempts to determine the dynamics and the accuracy of sensorimotor skills, which is responsible for the adolescent brain during ontogenesis and puberty. Only boys from each age 6 to 18 for were tested. Subjects perform a special test on a PC with a length of about 45 minutes to test their response and timing of movement with number of tests in which they try to hit a moving target, which appears on the screen at 3 different angles (0°, 15° and 30°) and at different speeds (accelerating, decelerating, constant). This whole process at unpredictable intervals in rotation for 45 minutes. We are expanding our previous results from 2016 in specific timing hits and miss shots in terms of age and frequency of PC gaming. Test data were evaluated from used program. Predictive motor timing suggests that the cerebellum plays an essential role in integrating incoming visual information with the motor output in a timely manner.

***Key words**: Sensorimotor skills, anticipation, timing of hits, adolescent, ontogenesis*

Introduction

Neuroscientists around the world in recent years have been trying to explore the role of cerebellum as part of the brain responsible for activity of basal ganglia and primarily for subconscious coordination of accurate rapid movements and balance in a number of human activities. We focused on the function of the cerebellum that affects the most accurate timing based on visual stimulation and the motor learning process. In this study, we use again a special test for the functions of the cerebellum detection, focused on timing operations. This test was previously repeatedly performed at the Neurological Clinic in Brno under the direction of Professor Martin Bareš. He examined the causes of timing in adult generation and older population affected by cerebral diseases. (Bareš, 2007) attempts to describe how strongly these diseases affect timing and what is typical for them. In this study, we come up with a similar methodology that we try to apply to the youth and to discover the course of the RT (reaction time) development. We tested the dynamics of the sensory-motor abilities developed by adolescents during ontogenesis (Gimunová, 2015, Vespalec, 2016). A number of neuropsychological studies have shown the importance of basal ganglia (Meck, 2005) and cerebellum in a wide range of movements (Braitenberg, 1967) or a role of motion timing and evaluation (Ivry, 2004) in the general population. Gibbon (1997), Iacoboni (2001) point to the importance of precise timing in sport, in the control of vehicles or at work. In recent years, efforts have been made to clarify the role of basal ganglia and cerebellum in the timing and accuracy of responses among people suffering from some of the disabilities of these parts of the brain, most commonly Parkinson's disease (Jahanshahi, 2010, Bares, 2010) and possibly other cerebellar diseases as essential tremors and spinocerebellar ataxia (Bares, 2010, Kiselev, 2008) on Russian children 4-6 years of age versus adults showed clear differences in the rate of response in this assay (Gescheidt, 2016), and the most recent study looking for common factors for early onset of these diseases Static stimuli were also carried out by a Belgian study (Debraband, 2012), a group of 80 children were measured (5-12 years of age). In special task, they tried to respond as quickly as possible to the (regular and irregular intervals), then repeat the same timing without a stimulus. Significantly better predictive timing in the irregular timing of children 9-10 years of age was found.

As the results of the middle age population were already obtained by prof. Bares, we have decided to carry out the same measurement on children from 6 to 18 years of age and find out whether and how they change during ontogenesis of motoric, timing and motor learning skills. In these early years, children are in a period of developments and stagnations, they should show up in the test. Our goal was to determine the level of timing and the accuracy of the reaction when describing the task and to describe partly the level of motor memory of children. We supposed to find changes that should be affected by puberty, eventually the relationships of different kinds of variables such as sports or playing games background.

Methodology

Testing was conducted using PC software created in LabVIEW 6.1TM environment, National Instruments, Austin, TX, USA. Setting of program task is taken from previous research (Bares, 2007) The sample comprised 41 kids from among schoolchildren. Only boys were tested. Informed consent was signed by children and parents as well. The file structure: individual years of primary and secondary schools in the file represented by two individuals designated by random selection. Test subjects perform a perception test on a PC with a length of about 45 minutes to test their response and timing of movement of the number of tests in which the individual tries to hit a moving target, which appear on the screen at different angles and in different speeds (accelerating, decelerating, constant), this whole at unpredictable intervals by rotation for about 45 minutes in 4 sections The first is training section, where tested pupils get used to shooting down a moving ball. This section also contains a series, where the ball changes color from green to red (to be pressed as soon as possible after the change in color) for control the level of the color discrimination. In the second and third part, which is key for us, is always 6 sets of 54 attempts with 20 seconds long pause. Throughout the test the students were supposed to sit 60 cm away from the screen and react with pressing the space bar. We used 10-minute-long questionnaire (medical background, level of sports activity, the level of PC gaming), two valid questionnaires (degree of sleepiness and anxiety). PC gaming has 4 values: 1- very often, 2 – regularly, 3 – very little, 4 – not at all. We compared four groups of children:

Table 1. Characteristics of the measured group of boys (own data processing)

Age groups	Avg. Age	Avg. PC Gaming	Avg. Tallness	Avg. Weight
• 6-8	7,2	2,3	139,5	37,9
• 9-11	9,9	2,8	146,7	42,5
• 12-14	13,3	3	163,3	57,9
• 15-18	16,3	2,8	177,4	72,1

The main interception task – *The moving green target travelling to the interception zone located in the right upper side of the screen, where the yellow cannon ball will intersect the target. The blue cannon in the lower right corner launched the yellow fireball traveling with constant speed to intercept the moving target. If the subject successfully intercepted the target, both balls exploded (animated with small red points). No animation occurred, if the subject failed to intercept the target. Subjects had to push the fire button at the instant the target ball reached the interception area. If subjects were successful, the target exploded.*

Results

We take our measurements and we decided to compare them from 2 points of view. We supposed that there are some statistically significant correlations in terms of frequency of PC gaming among these 4 age groups. First of all, we compared the number of hits, early errors and late errors from the whole task (2,3 block) with the PC gaming variable. Spearman's nonparametric correlation coefficient was used for the calculations on the whole group and for each age category. Due to our goal, were only interested in the PC gaming column. In all age groups comparison, we did not find even moderate dependence of PC gaming with type of hit (Tab. 2)

Table 2. Hits and errors ratio, correlations for all age groups (own data processing)

Variable	All Groups			
	hits	early errors	late errors	PC gaming
hits	1,000000	0,154349	-0,455282	0,081223
early errors	0,154349	1,000000	-0,118016	-0,024098
late errors	-0,455282	-0,118016	1,000000	-0,070852
PC gaming	0,081223	-0,024098	-0,070852	1,000000

Table 3. Hits and errors ratio, correlations for 9-11 age group (own data processing)

Variable	age group "9-11"			
	hits	early errors	late errors	PC gaming
hits	1,000000	0,273557	-0,626143	-0,560953
early errors	0,273557	1,000000	-0,878788	-0,275897
late errors	-0,626143	-0,878788	1,000000	0,514510
PC gaming	-0,560953	-0,275897	0,514510	1,000000

The highest correlations were found for the age group 9-11 years (Tab. 3). Indirect rate (-0.56) with variable “hits” and direct dependence (0.51) with variable “late errors”. It means that higher level of gaming led to higher number of hits whereas higher PC gaming caused less late errors. For the age group of 15-18 years the highest correlation was the direct dependence on the variable “hits” (0.51). All the other correlations were insignificant.

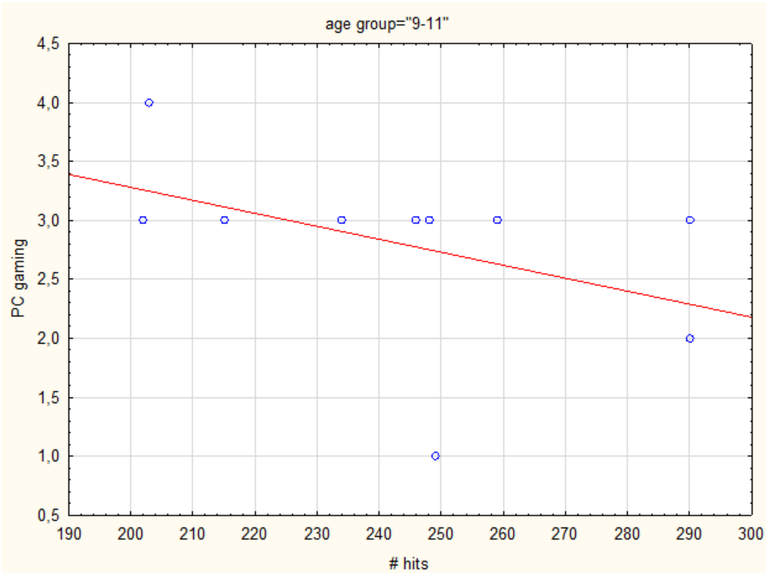

Figure 1. Hits and errors ratio, correlations for 9-11 age group (own data processing)

The second part of the comparison was focused on the relationship of the PC gaming level with the mean value of positive and negative deviation from the hits time space. In this part of study, we discovered the most crucial correlation in 9–11 age group (Tab. 4), where results assume that more often gaming children have the little lower mean value of late error shots in the task, which correspond with the data from previous table with late error hits. We also had interesting value of higher PC gaming level in the next age group (Tab. 5). Moderate dependence value of early errors which led children closer to hits in the task.

Table 4. Errors mean deviation ratio, correlations for 9-11 age group (own data processing)

Variable	age group "9-11"		
	mean deviation early errors	mean deviation late errors	PC gaming
mean deviation-early errors	1,000000	-0,309091	-0,320637
mean deviation-late errors	-0,309091	1,000000	0,633817
PC gaming	-0,320637	0,633817	1,000000

Table 5. Errors mean deviation ratio, correlations for 12-14 age group (own data processing)

Variable	age group="12-14"		
	mean deviation early errors	mean deviation late errors	PC gaming
mean deviation-early errors	1,000000	-0,624242	-0,570385
mean deviation-late errors	-0,624242	1,000000	-0,019668
PC gaming	-0,570385	-0,019668	1,000000

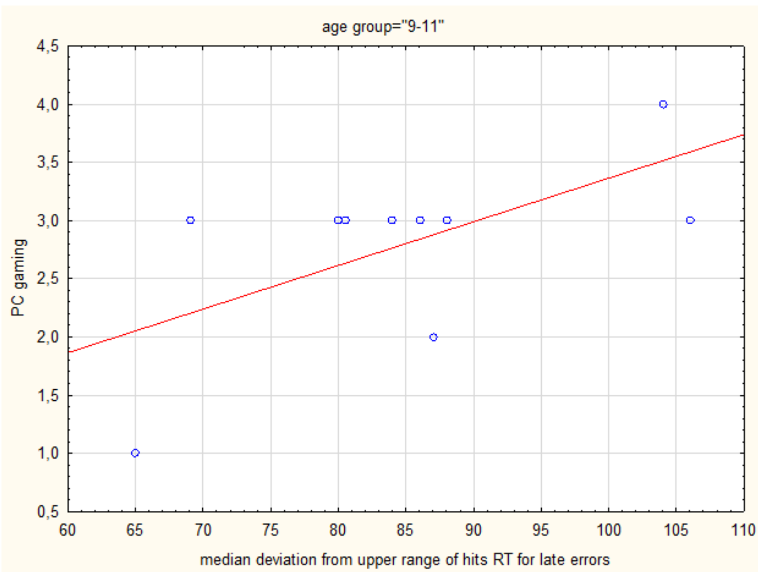

Figure 2. Errors mean deviation ratio, correlations for 9-11 age group (own data processing)

Discussions

In this research, we tried to understand better differences in precise reaction timing during the PC gaming in adolescent population. In previous similar research we found conformity for our results. In older studies (Griffith, 1983) compared 31 video game users and 31 non-users. Results showed that users have significantly better eye-hand motor coordination on a pursuit rotor. However, they didn´t found any relationship between an individual's eye-hand motor coordination and the amount of time spent weekly playing video games or the length of experience with video games. Also on kids (4 to 6 years) there were no significant differences between the two groups in correct responses found…however, RTs of players were significantly faster than those of non-players (Yuji, 1996). Video games players also showed overall faster response time for easy and difficult visual search tasks compared to non-video games players, largely attributed to faster stimulus-response mapping (Castel, 2005). According to (Mack, 2016) video game players exhibited higher peak and mean performance than non-video game players, however no any differences in the speed of covert attention shifts, 98 males were tested. (Bădău, 2016) tested the group of 60 people from physical education faculty to find out that left hand has the shorter RT in simple visual reaction test across left and right handers, and gets better in males. There also might be benefits of casual video game playing to attention and relevant everyday skills, and these games may have potential value as training tools, like game Bejeweled Blitz (Stroud, 2015).

Our results have shown that in golden age of motoric age (9-11) there might be some smaller changes in reaction and hits ratio in PC task during ontogenesis. Hit ratio is increasing with the level of gaming, which is the opposite of what could be expected. At the same age group (9-11) mean deviation of late errors is going down with higher PC gaming experience and in next group (12-14) is mean deviation of early errors going up with PC gaming. Despite all of this we can't indicate overall results as significant trend.

Conclusion

Results in mean deviation aspect are relatively ambiguous and in neighboring age groups have contradictory correlations. All the other available results in all age groups are statistically insignificant. We find out that there are no major differences across age groups, which is consistent with previous research. At the same time, we confirm the claim that some age groups might be better in hits ratio, but not better in proximity of errors in the PC gaming point of view. Our results may be unfortunately influenced by number of limitations. Firstly, small sample of participants overall. There should be more extensive research with much wider sample. Another limitation is the concentration rate of children and of course the type (speed) of games they play. This all should be a task for next research in the future in similar studies.

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ANALYSIS OF THE GAME CHARACTERISTICS OF A FINAL JUNIORS MATCH U14 AT WORLD JUNIOR TENNIS FINALS – WJTF IN 2014 (CASE STUDY)

Janák Ondřej, Pačes Jiří, Zháněl Jiří
Faculty of Sport Studies, Masaryk University Brno

Abstract

Analysis of the course of a match serves as a feedback tool in many sports (e.g. football, basketball, volleyball, tennis), the results of which are subsequently used in the training process. In tennis, the most common method is analysis of the game characteristics, which is being used before the match as well as during the post-match analysis. Curently a specialized computer software is being used w hich replaces previously used manual analysis methods. The advantage of using the software is less time-consuming, immediate data processing and gaining results. Analysis results of game characteristics from major tennis tournaments are commonly available online in electronic form, even several years back. When selecting the analyzed game characteristics, we used the IBM Slam Tracker software which is used in all Grand Slam tournaments. We analysed the game characteristics of the participants of World Junior Tennis Finals (WJTF) in 2014 in Prostejov. The aim of this study, based on the research data analysis, was find out the differences in the level of 13 chosen game characteristics of the winners and defeated junior finalists (n=4) and also to verify whether there are significant differences bethween the junior and adult players‘ results at Roland Garros 2014. From the recorded video of the final matches of Canada (CA) and Germany (DE), the game characteristics were analyzed using the Dartfish 9.0 software. The results of the WJTF 2014 finalists‘ analysis showed that in the first match (NK vs. FA) the winning FA tennis player presented himself with the more aggressive concept of the game. Player FA scored 3 aces, 17 winners (16 of which were from forehand) and 11 successful actions on the net. The equilibrium of the opponents shows a small difference in the total number of points gained (NK 88; FA 96). In the second match (RM vs. NM players), the defeated NM player made a total of 7 doubles, his success rate of first serve was only 56 %, also the NM player also scored 18 unforced errors, and gained only 26 points (comparing to 55 points of the winner). While in the first match a total of 184 points were scored, only 81 points were scored in the second match, which is indicating the unequivocal course of the second match.

The comparison of the game characteristics of the two junior finals showed that the difference between the winners and defeated players was mainly the number of aces, points scored after first and second serves and total number of points scored. Based on a comparison of the level of game characteristics of Junior (WJTF) and adult finalists (Roland Garros) in 2014, it can be noted that adult players have been able to benefit more from their first serve and also gain more points after the second serve of their rival than juniors. Also, breaking the opponent's serve was more important factor and in this case the decisive one.

Key words: *game analysis, match statistics, sports performance, software, tennis, comparsion*

Introduction

Analysis of the game characteristics is a significant element of feedback for both coaches and players in a range of collective and individual ball games. In tennis, the usage of analysis of the game characteristics became a part of training process, not only as a tool for pre-match preparation and the choice of appropriate strategy and tactics, but also part of an analysis after the match. A number of coaches use the analysis of game characteristics to reveal the strengths and weaknesses of the players and to subsequently use this knowledge in training, not only in tennis (Hohmann et al., 2007; Vencurik, & Nykodym, 2017; Schönborn, 2012). Crespo & Miley (2003) recommend using the analysis of game characteristics to formulate training goals, strategy and tactics evaluation, psychological readiness, and understanding the opponent's game. Previously used manual methods of game characteristics analysis (Bykanova-Yudanov, 2011; Schönborn, 2012) was gradually replaced by special software for game analytics not only in tennis, such as SIMI Scout, Dartfish, Silicon Coach, Tennis Analytics, TennisStats (Hui, Lijuan & Jinju, 2010). Currently, the analysis of the game characteristics of the most important tournaments can be seen both during and after the match on TV screens, or can be searched on the Internet. One of the most commonly used IBM SlamTracker software evaluates 12 game features and is used on all four grandslam tournaments. The match data are available on-line on the internet and detailed analysis is available to both players and coaches after the match. Game statistics from tournaments (both current and finished) can be found on dedicated websites (such as www.matchstat.com, www.atpworldtour.com or www.oncourt.info). Dartfish company offers software to evaluate predefined game pointers. The evaluation is performed on the principle of tagging game events during the match, or video-recording. Based on the results of the serve analysis, Brody (2004) ascertained that for the winning of the serve, the high percentage of first serve in is not decisive, but the high percentage of points won after first serve is. Filipčič, Čakš & Filipčič

(2011) mention that statistical analysis of the match characteristics enables understand the causes of loss or victory in the match. Based on the analysis of 93 matches of 57 tennis players, authors were investigating, in which game characteristics there are significant differences between winning and defeated player. It has been found that winning players have scored significantly more points earned after the serve and more total points won then defeated players. Sanz & Terroba (2012) indicate that the most important element in the analysis process is not the available information but their correct interpretation and transfer to coaching practice. O'Donoghue & Ingram (in Filipčič et al., 2011) also saw a significant difference in the total number of aces in Wimbledon (there were more aces) and on Roland Garros. The huge amount of grandslam tournaments data in 1995-2009 was analyzed by Cross & Pollard (2009), who were deriving data from post-match statistics on the official website of the relevant Grand Slam. The authors have found that the number of aces is generally increasing due to the increasing serve speed, vice versa the number of double faults decreases. They also found that most of the aces are noted every year during the Wimbledon tournament, followed by the US Open, the Australian Open and the French Open (this sequence is closely related to the surface). In another study, Cross & Pollard (2011) present the fact that a third of all rallies is finished by the winners and another third by unforced errors. Based on the above-mentioned synthesis of the findings the research objectives were formulated by analyzing the game characteristics of the final matches of the world's best juniors – participants of the World Junior Tennis Finals (WJTF) in 2014 in Prostějov (Czechia). The text conceptually follows on studies by Bačo (2012) and Polach et al. (2016).

Methods

The WJTF 2014 tennis finals were video recorded. The research data were obtained from the recording of each match by the observation method using the Dartfish 9.0 software. Individual game characteristics were selected based on the analysis of foreign studies, publications, statistical software and consultations with tennis trainers and experts. To compare the differences in game characteristics of juniors (WJTF 2014) and adult players (Roland Garros 2014 men‘s final) qualitative expert assessment method was also used. Based on IBM SlamTracker software the 13 most important game characteristics were selected:

number of aces
number of double faults
success rate of first serve in (%)

number of points won after first serve
number of points won after second serve
number of return points won
number of forehand winners
number of backhand winners
number of forehand unforced errors
number of backhand unforced errors
number of net points won
success rate of breakpoints won (%)
number of total points won

The teams of Germany and Canada (n = 4) competed in the final matches of the WJTF 2014. All observed juniors were 14 years old. The first match was played by FA (CA) and NK (DE) with the result 7:6(4), 7:5 for Canadian player. In the second match, NM (CA) and RM (DE) played and German player won 6:1, 6:2. The research data were compiled into tables, which enabled to compare the individual game characteristics of both the winner and the defeated player. Based on the synthesis of knowledge, we have formulated two research questions:

What is the difference in the level of game characteristics of winning and defeated players in WJTF final matches?

Are there significant differences in the level of game characteristics of junior and adult players?

Results

The participants of the first final match were NK (DE) a FA (CA), who won (6:7, 5:7). The results of game characteristics analysis are listed in Table 1.

Table 1. Analysis of observed game characteristics (first match)

Game characteristics/Players	First set		Second set		Match	
	NK (DE)	**FA (CA)**	NK (DE)	**FA (CA)**	NK (DE)	**FA (CA)**
1. Aces	0	2	0	1	0	3
2. Double faults	0	3	1	0	1	3
3. First serve in (%)	40/51 78%	24/41 59%	24/32 75%	37/52 71%	64/83 77%	61/93 65%
4. Points won after first srv.	21	16	12	19	33	35
5. Points won after second srv.	7	9	5	10	12	19
6. Return points won	19	23	24	15	43	38
7. Winners - forehand	1	8	1	8	2	16
8. Winners - backhand	2	1	3	0	5	1
9. UE - forehand	4	8	3	11	7	19
10. UE - backhand	16	17	10	12	26	29
11. Net points won	0	6	1	5	1	11
12. Breakpoints won (%)	2/3 67%	2/6 33%	2/6 33%	3/6 50%	4/9 50%	5/12 42%
13. Total points won	47	50	41	46	88	96

Notes: bold text ... winning player; UE ... unforced errors

Table 1 shows that the Canadian player FA was more active, as evidenced by both a higher number of unforced errors and more than double the number of winners than his opponent. The Canadian player played 16 forehand winners of the overall 17. German player NK made only 7 forehand unforced errors during the whole game. He has a confidence in both his forehand and his serve. The NK player scored a much higher number of backhand winners than his opponent, but the backhand unforced errors were almost four times more than forehand unforced errors. A large number of games that have been played in deuce results in the high of total points won by both players. The winning player earned only 8 more points than defeated player and won nineth match point. The difference in the number of points won shows the balance of the match. The difference aspect that has probably decided the result of the match was the greater activity of the Canadian player FA.

The player RM from Germany and player NM from Canada competed in the second match. The German player was the clear winner (6:1, 6:2). As showed in Table 2, the second final match had unambiguous course unlike the first one.

Table 2. Analysis of observed game characteristics (second match)

Game characteristics/Players	First set		Second set		Match	
	RM (DE)	NM (CA)	**RM (DE)**	NM (CA)	**RM (DE)**	NM (CA)
1. Aces	4	0	1	0	5	0
2. Double faults	0	5	2	2	2	7
3. First serve in (%)	16/21 76%	4/9 44%	10/16 63%	14/21 67%	26/37 70%	18/30 56%
4. Points won after first srv.	11	3	8	4	19	7
5. Points won after second srv.	4	2	3	3	7	5
6. Return points won	4	6	14	5	18	11
7. Winners - forehand	2	1	3	3	5	4
8. Winners - backhand	0	2	0	1	0	3
9. UE - forehand	3	3	1	2	4	5
10. UE - backhand	2	7	1	6	3	13
11. Net points won	0	0	0	0	0	0
12. Breakpoints won (%)	2/2 100%	0/0 -	3/4 75%	1/1 100%	5/6 88%	1/1 100%
13. Total points won	27	12	28	14	55	26

Notes: bold text … winning player; UE … unforced errors

German player RM had better first and second serve (scored 5 aces and only 2 double faults). Thought, in the second set, there has been a slight deterioration in all game aspects, especially in the number of first serve in, however, a total of 70% of the first serve success rate can be considered as above-average. Canadian player NM lost 5 serve games, made 18 unforced errors, 7 double faults, and won only 12 points after his serve. German player RM gained more than twice as many total points as his Canadian rival RM and made only 7 unforced errors. Interestingly, no single net point was scored in the match.

Comparison of final matches – analysis of observed game characteristics

This comparison helps to clearly compare the game characteristics of both final matches. The results of the comparison are influenced by the difference in the number of games played in both matches. A total of 25 games (tie-break counted as one game) and 184 points were played in the first match, whereas in the 2nd match only 15 games and 81 points were played. The winner of the first match, Canadian player FA, had to score 96 points to win, to become a winner of the second match was enough to score 55 points. Player RM scored a several times smaller number of unforced errors but also proportionally smaller number of winners in the second match. Canadian player FA scored a total of 17 winners in the first match, which is the highest number of all four players in the final singles (other players scored 7, 7 and 5 winners). In the second match, German tennis player RM got 5 breakpoints out of 6 opportunities, his Canadian rival (NM) won only 2 games after his serve. The winner of the second match has more than twice the total number of points won against the defeated player.

Discussion

Comparison of first and second final match of WJTF 2014 with final match of WJTF 2013

With the results of WJTF 2013 (Polách et al., 2016), we can compare our analysis of the first WJTF 2014 match between NK (DE) and FA (CA) for a similar number of points played. Unlike the winning players in 2014, the winning player in 2013 played a smaller number of aces, but also less double faults than the defeated player. Only in the first final match of WJTF 2014 the percentage of first serve in of winning player is smaller than percentage of first serve in of defeated player. The amount of points won after the serve is consistently higher for all winning players in both WJTF 2013 and 2014, while the numbers of return points, the winners and the unforced errors are different. The more active winning players in the first match of 2014 and the match in 2013 are characterized by a higher number of winners, unforced errors and net points won. All winning players scored a higher number of breakpoints as well as a total points won. In general, the finalists in 2013 PK (US) and PL (RU) played more risky, as evidenced by a larger number of winners, but also unforced errors. There was no significant difference among other game characteristics.

Comparison of first and second final match with Roland Garros 2014 men final (RG)

When comparing the game characteristics of these matches, it is necessary to take into account the fact that there are best of five sets matches on the RG. The number of total points is generally higher. We wanted to point out the important differences between relevant game characteristics of junior and adult matches by this comparison. Limitation of this comparison is only 8 game characterictics of RG 2014 men final available.

Table 3. Comparison of first and second final match of WJTF 2014 with Roland Garros 2014 men final

Game characteristics / Players	First match		Second match		RG 2014 men final	
	NK (DE)	**FA (CA)**	**RM (DE)**	NM (CA)	ND (RS)	**RN (ES)**
1. Aces	0	3	5	0	11	3
2. Double faults	1	3	2	7	3	4
3. First serve in (%)	64/83 77%	61/93 65%	26/37 70%	18/30 56%	82/126 65%	84/120 70%
4. Points won after first srv.	33	35	19	7	59	61
5. Points won after second srv.	12	19	7	5	16	18
6. Return points won	43	38	18	11	75	79
12. Breakpoints won (%)	4/9 50%	5/12 42%	5/6 88%	1/1 100%	3/9 33%	6/10 60%
13. Total points won	88	96	55	26	116	130

Notes: bold text … winning player

Based on the analysis of the game characteristics in table 3, it can be stated that the junior winning players have scored a higher number of aces (3-0, 5-0), the RG winning player was the opposite (3-11). Winning players in both juniors and adults reached a higher number of points won after the first (35-33, 19-7, 61-59) and second serve (19-12, 7-5, 18-16). The succees rate of first serve in is comparable in both categories. Most successfull in this characteristic was defeated player NK from the first match (77%), he also gained more return points than his opponent (43-38). The winning players of both RG men final and the juniors second match has higher percentage of first serve (70%-56%) in and scored larger number of return points won 18-11, 79-75). A number of aces and double faults shows that the success of the tight RG final match was not based on the serve but the breakpoints won (6-3). The winning juniors also recorded a higher number of breakpoints won (5-4, 5-1). Both RG and junior winning players earned a higher number of total points won (96-88, 55-26, 130-116). In general, the RG 2014 finalists won more points after 1st serve than juniors but less points after second serve. A number of return points won is higher in men final (all in proportion to the total points won). Filipčič, Filipčič & Berendijaš (2008) in RG 2005 analysis found out that the winning players played more aggressive – scored more aces and net points won, also made less double faults and scored a higher first serve in. Conclusions from the game characteristics analysis of the RG 2011 final were made by Schönborn (2012). He found that the winner was more successful due to twice less the number of unforced errors.

Conclusion

Based on analysis and comparison of the game characteristics of the final matches of WJTF 2014, we can say that the difference in level of the game characteristics of winning and defeated players is verifiable. In the first tight match, the difference aspect was the higher number of winners and net points won by the winning player. The clear second match was characterized by a significant difference in the level of serve and the number of breakpoints won. When comparing the level of game characteristics of juniors and adult players, it was found that there were significant differences in the importance of return points won and the breakpoints won. Obtaining breaks has greater impact on adult players than on juniors. From the above conclusions, it is recommended to use analysis of the game characteristics for coaching practice, ideally after each match. Based on the larger amount of collected and subsequently analyzed data, it is possible to focus on the more problematic aspects of the game and thus to make the training process more effective, especially in the tactical part.

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BILATERAL KINEMATIC INDICATORS OF THE SPECIFIC HIP AND KNEE POSTURAL ADAPTATION OF HANDBALL PLAYERS

Kiseljak Dalibor[1,2], Pažin Krešimir[1], Bolčević Filip[1]
[1]University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia
[2]University of Applied Health Sciences, Zagreb, Croatia

Abstract

Purpose: Considering the everyday training, handball players promote specific postural adaptation. Determining of postural and functional unilateral sports inherent asymmetry could improve the performance and provide injury prevention. The aim of this study was to examine whether there were significant differences in hip and knee range of motion (ROM), in all planes, between stance and kicking leg of handball players.

Methods: Research was conducted in the Laboratory for biomechanics of the Institute of Kinesiology at the Faculty of Kinesiology, University of Zagreb, during May 2016. Assessment was performed in 2 stages, on a randomized sample comprised of 25 male subjects, age ranging from 19 to 24 years with a mean 21.8. Participants were recruited from the population of students who train handball 10.44 ± 3 years. Based on the short version of the International Physical Activity Questionnaire (IPAQ), a high level of physical activity of the participants was determined. Kinematic measurements were performed through the Modified Thomas Test (MTT), which is standard for sagittal evaluation of the passive hip extension and knee flexion, giving the information on the flexibility of monoarticular and biarticular hip flexors, whose segmental postural adaptation can generate end movements in other planes. Therefore, the sample of variables were 4 angles: knee flexion and hip extension, rotation and abduction, all bilaterally.The research was performed using automatized optoelectronic kinematic measurement system ELITE 2002 (BTS Bioengineering Corp., Milano) with 8 cameras, frequency 100 Hz and 9 passive markers placed at bony prominences. Data processing was done using the Smart Analyzer software package. Since distribution showed normality, the t-test for independent samples was used. Calculations were performed using Statistica 12 software package.

Results: Kicking leg was more mobile in the hip, through the extension ROM (2.36°, $p=0.18$), and especially in the frontal plane where significantly higher abduction angle was found (2.55°, $p=0.03$). Knee ROM was greater for the stance leg, although no significance was found (1.56°, $p=0.45$). Posture in the horizontal plane was neutral for both legs.

Conclusions: Handball players are characterized by greater mobility of the kicking leg in the hip. With the exception of hip abduction, this study has not found

that multi-year handball training forms a postural adaptation of the lower extremities with significant bilateral asymmetries. Bilateral kinematic indicators determined in this study could contribute to a better understanding of the role of segmental hip and knee movements in posture, postural adaptation and locomotion of handball players, and provide guidelines for the prevention and rehabilitation of neuromuscular deficits and their consequences.

Key words: *unilaterality, stance leg, kicking leg, ROM, Modified Thomas Test, optoelectronic kinematic measurement*

Introduction

Handball is a highly strenuous contact team sport with a strong emphasis on running speed, jumping, abrupt changes in direction, and throwing (Gorostiaga et al., 1999, as cited in Setuain et al., 2015). Team handball is an attractive dynamic sport game that is very popular in Europe as well as countries in Africa, South America and Asia. In most of these countries, team handball is practiced and played often professionally (Wagner et al., 2017). Handball performance is, to some extent, affected by the anthropometric characteristics of athletes and it is possible that such characteristics differentiate players of a different competitive level (Milanese et al., 2011, as cited in Ghobadi et al., 2013). Due to the everyday training, handball players develop specific postural adaptation encompassing joint, muscular and connective tissue structures of the locomotor system as well as the central nervous system. Handball is characterized by changes in the role of musculature, from stabilization to mobilization, with different types of contractions. The athletic performance in handball depends on the athletes' health and quality of movement, that is, among others, based on posture and postural control.

Postural and functional asymmetry detection could help in prevention of the potential imbalance patterns that may promote among handball players. In advance to the higher injury risk associated with muscular imbalances, athletic performance could also be impaired through the absence from the training and/or the modification of technique due to health reasons. Muscular imbalance is a term frequently used in the area of sport performance, injury prevention and rehabilitation, describing substantial deviation from normative data or muscle performance differences between limbs. Such imbalances are associated with poor performance and higher injury risk. Previous injury, or specific sport demands, have been suggested as possible reasons that could result in the development of bilateral muscle strength imbalances among athletes (Rahnama, Lees & Bambaecichi, 2005). Previous studies have shown bilateral strength imbalances to be present in well-trained athletes (Jones & Bampouras, 2010;

Rahnama et al., 2005). It is known that athletes with insufficient postural mechanisms have an increased injury risk (Han et al., 2016; Nagai et al., 2013; Switlick, Kernozek & Meardon 2015). In handball these aspects are more pronounced because of the sports technique, which dominantly requires unilateral performance. The problem arises in insufficient focus on preventive and corrective exercises during training. Evidence of postural and functional asymmetries can be a helpful tool for a safe and efficient movement, with injury prevention and thus improved athletic performance.

Foot velocity is influenced by a sequential summation of forces from muscles acting around the pelvis, hip, knee and ankle joints (Young et al., 2003). Both the hip and knee have been implicated as influencing the strain placed upon the anterior cruciate ligament (ACL), with frontal and sagittal joint angles and moments identified as injury risk factors (Greska et al., 2016). When assessing the hip in association with other joints, it is important to observe the knee and lumbo-pelvic complex. Lower limb bilateralism with neuromuscular differences between stance and kicking extremity, may affect patterns in the background of sports performance. Gomes, de Castro & Becker (2008) suggest that examining the hip ROM should become a routine part of the decision-making process in football players with unstable knees.

The aim of this study was to examine the hip and knee posture and postural adaptation among handball players. Therefore, the purpose of the research was to recognize bilateral indicators of postural adaptation for optimizing performance including injury prevention that plays an important role in the quality of handball training and competition. Clinical test that can provide useful information regarding postural adaptation is the Modified Thomas Test (MTT). No scientific report has been published showing the kinematic analysis of MTT among handball players. The objective of this study was to examine whether there were significant differences in hip and knee ROM, in all planes, between handball players' kicking and stance leg. It was hypothesized that a difference would be noted for leg dominance, with the stance leg displaying more stability, in relation to the more mobile kicking leg. The assumption underlying this research is that this segmental clinical test of flexibility has predictive ability in relation to dynamic activities.

Methods

Research was conducted in the Laboratory for biomechanics of the Institute of Kinesiology at the Faculty of Kinesiology, University of Zagreb, during May 2016. Assessment was performed in 2 stages, on a randomized sample comprised of 25 male subjects (1.84 ± 0.59 m, 84.8 ± 9.57 kg) age ranging from 19 to 24 years with a mean 21.8. Participants were recruited from the population of students who train handball

10.44 ± 3 years. The reported data consisted of 50 lower extremities. Kinematic measurements were performed using the MTT, standardized observational clinical test for posture and lower extremity kinematics postural adaptation assessment through sagittal evaluation of the passive gravitational hip extension and knee flexion, giving the information on the flexibility of one-joint and two-joint hip flexors, whose segmental postural adaptation could generate end movements in other planes as well. Objectification of the test usually includes 2D goniometric and trigonometric methods, and in this research the 3D kinematic analysis of MTT was applied. The research was performed using automatized optoelectronic kinematic measurement system ELITE 2002 (BTS Bioengineering Corp., Milano) with 8 cameras, frequency 100 Hz and 9 passive retroreflective markers placed at bony prominences: acromion L&R, ASIS L/R, medial femoral epicondyle L/R, lateral femoral epicondyle L/R, medial tibial epicondyle L/R, fibular head L/R, medial malleolus L/R, lateral malleolus L/R. The study was approved by the Faculty's Ethics Committee and all subjects provided written informed consent to participate. At the time of the examination, no respondent has had any injuries or surgery for three years, as evidenced by a specially constructed anamnestic questionnaire. Each participant was measured by the same examiner (the principal examiner was a master physiotherapist with 11 years of clinical experience), according to the same procedure (positioning of the participants, marker placement), at the same time of the day (am), with the most similar atmospheric conditions. Two kinesiologists, with 3 and 4 years of clinical experience, took part in the research, making the anthropometric evaluation, the computerized data recording and the adjustment of measuring tools between sequences of the examination. The subjects did not have intense physical activity minimally 12 hours prior to examination. The kicking leg is defined as the leg that the participant would use to kick a ball. The non-kicking leg was handball player's stance leg. The extremity first to be measured was randomized by a coin method. After marker placement, participants were positioned for MTT (Figure 1) and given instructions for performing the test according to the protocol, based on the relevant literature (Cheatham & Kolber, 2016; Harvey, 1998; Kendall et al., 2005; Magee, 2006). The test was repeated for the other limb.

Figure 1. Modified Thomas Test protocol

Flexibility of *m. iliopsoas* was assessed by measuring hip extension ROM, thus of *m. rectus femoris* by measuring along with knee flexion ROM. Flexibility of *m. tensor fasciae latae* was assessed by measuring hip abduction ROM in the frontal plane, with hip internal rotation ROM in the transverse plane. Kinematic data from MTT were collected using automatized optoelectronic system ELITE 2002. Measurement and data acquisition were performed using the GaitEliClinic software package, a part of the BTS ELITE 2002 system. Furthermore, data processing was performed using the SmartAnalyzer software package. The features of the BTS system enable measurement with high spatial and temporal resolution, and automatic detection and acquisition of a 3D trajectory coordinates of a number of markers. The system functions based on automatic detection of coordinates of retroreflective passive markers by the method of cross-correlation, and by employing close-range photogrammetry algorithms for calculation of 3D marker coordinates. When marker trajectories are acquired, a number of kinematic parameters of a particular recorded movement can be calculated (Medved, 2001). In total, 400 angles were computed while 6 fell out the experiment, due to sweating, 3D method artefacts and trick movements. The sample of variables were 4 angles: knee flexion, hip extension, hip rotation and hip abduction, all bilaterally.

Normality in data distribution was examined using the Kolmogorov-Smirnov test. The level of significance was set at $p = 0.05$. After the whole data showed normality, group differences were evaluated using the t-test for independent samples. Significance was accepted at the $p \leq 0.05$ level of confidence and all results are reported as mean ± SD. All data were analysed by the Statistica 12 software package.

Results

Optoelectronic kinematic evaluation results are presented in Figure 2, showing that kicking leg was more mobile in the hip, through the extension ROM (**25.84° ± 9.1°** / *23.47° ± 8.22°* \2.36°, p=0.18), and especially in the frontal plane where significantly higher abduction angle was found (**9.03° ± 6.9°** / *6.48° ± 4.8°* \2.55°, p=0.03). Knee ROM was greater for the stance leg, although no significance was found (*54.32° ± 10.91°* / **52.76° ± 9.71°** \1.56°, p=0.45). Posture in the horizontal plane was almost neutral for both legs (*0.4° ± 4.22°* / **0.06° ± 5.23°** \0.34°, p=0.72).

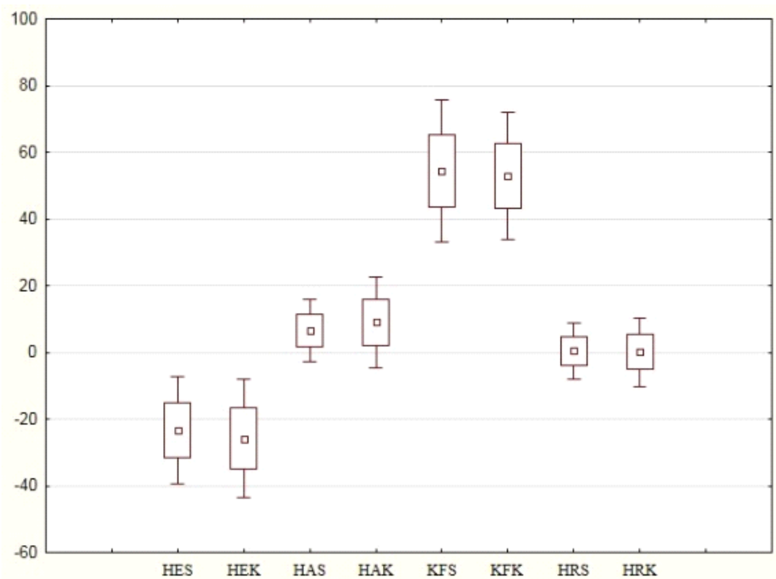

Figure 2. Results of measuring 4 ROM parameters bilaterally: **HES** – stance leg hip extension, **HEK** – kicking leg hip extension, **HAS** – stance leg hip abduction, **HAK** – kicking leg hip abduction, **KFS** – stance leg knee flexion, **KFK** – kicking leg knee flexion, **HRS** – stance leg external hip rotation, **HRK** – kicking leg external hip rotation

Discussion

The aim of the present study was to investigate the application of MTT for the assessment of lower limb bilateral imbalance among handball players. Examination of the lower extremity muscle length was performed indirectly, by testing hip and knee ROM of kicking and stance leg, compared side-to-side. No significant differences between limbs were found, with the exception of the hip abduction ROM, which was significantly greater for the kicking leg. According to Bradley & Portas (2007), previous literature has postulated that a lack of muscle flexibility is an important intrinsic risk factor for the development of muscle strain injuries in sport. In their research, aforementioned authors found no significant relationships between muscle strain injury and limb dominance intrinsic risk factor, which opposes the findings of previous studies. Our main results showed more mobility in the hip for the kicking leg, significant only in the variable hip abduction. In the knee the stance leg showed more mobility, but without significance. In handball, the basic offensive position, as well as most of the attack movement solutions, aligns the kicking leg predominantly externally rotated and abducted; e.g. during the jump shot, the kicking leg is used to achieve the additional impulse that is obtained at the take-off level. Initially, kicking leg is flexed in the hip and knee joint, followed by extension in the two joints to achieve additional impulse when throwing the ball. Throughout the whole cycle the kicking-side thigh is abducted and the iliotibial region is constantly loaded, promoting specific postural adaptation. That could be the explanation of the increased hip abduction ROM for the kicking leg, found in the present study.

Hip extension is considered to be important in performing various sport activities. A lack of hip extension has been theorized to lead to an over striding gait and increased impact forces during running (Derrick, Hamill & Caldwell, 1998). Husson et al. (2010) point out the lumbo-pelvic-hip complex as a paradigmatic entity in the human posture analysis, with structural and functional connections to the spine and lower extremities, while Page et al. (2010) elaborate various compensatory mechanisms in postural adjustment, considering the lower crossed syndrome as a guide in assessment and intervention. Lazennec, Brusson & Rousseau (2013) investigated the role of lumbosacral and pelvic regions in the continuity of functional spinal parameters, emphasizing posture and postural adaptation of the hip as a key aspect, but underestimated beside the conventional assessment approaches. There are studies (Buckeridge et al., 2012; Holt et al., 2003) that emphasize the importance of the full range of hip movements for the spinal load reduction. For individuals with low back pain, tight hip flexors may lead to compensatory spinal movements that increase spinal extension, as the individual lacks movement options due to their hip extension limitations (Vigotsky et al., 2016). A lack of hip extension may be associated with tightness in the hip flexor muscles. Postural perspective related to hamstring strains is that tight hip flexors lead to an anterior pelvic tilt, which may predispose sprint athletes to hamstring strains (Gabbe, Bennell & Finch, 2006). On their research results, Bradley & Portas (2007) suggest that preseason muscle flexibility assessment, particularly for the hip and knee flexors, is essential in elite football players to identify players with reduced ROM. Therefore, it is recommended that for athletes identified as having an "at-risk" ROM should be prescribed an appropriate flexibility training program.

Imaging studies that have assessed the role of cortical activity in simple joint movements of the hip, knee and ankle, reported that the stance leg produces a more bilateral cortical activation pattern, whereas the kicking leg produces a predominantly contralateral cortical activation pattern (Kapreli et al., 2006, as cited in Greska et al., 2016). Brown, Palmieri-Smith & McLean (2009) performed the jump-to-cut task using college-aged recreational athletes, and found that stance leg displayed greater joint excursions for hip and knee joint angles compared to the kicking leg. Brophy et al. (2010) suggested that the limb dominance might be factor in the etiology of ACL injuries, since females were more likely to injure their stance leg. Evidence for neuromuscular or biomechanical risk factors for ACL injuries in male athletes appears to be mainly related to dysfunctions occurring at the trunk and hip joint levels (Alentorn-Geli et al., 2014, as cited in Setuain et al., 2015). According to Young et al. (2003), reduced extensibility of tissues around the hip and knee joints are thought to be related to injury risk. The relationship between the static measure of flexibility and the hip and knee positions achieved during kicking was stronger than in previous research that investigated gait. The studies using gait involved submaximal speeds, which might have not required a high level of hip flexibility.

Potential disadvantage of the present study relies on the complex comparison between segmental assessment, gait analysis and handball specific motion in training and competition, from the postural and functional aspects. Nevertheless, segmental tests could give guidelines for corrective sport performance exercises in the context of holistic prevention. The findings of Jones & Bampouras (2010) provide support for the use of field tests to detect imbalances between lower limbs.

Conclusion

Handball players are characterized by greater mobility of the kicking leg in the hip. With the exception of hip abduction, this study has not found that multi-year handball training forms a postural adaptation of the lower extremities with significant bilateral asymmetries. Bilateral kinematic indicators determined in this study could contribute to a better understanding of the role of segmental hip and knee movements in posture, postural adaptation and locomotion of handball players, and provide guidelines for the prevention and rehabilitation of neuromuscular deficits and their consequences. The results support the use of segmental clinical tests in lower limb asymmetry detection, allowing kinesiologists and/or physiotherapists to determine whether an athlete is in need of a training program that emphasizes additional exercises for improvement of the bilateral postural balance. The knowledge gained from this research could be especially useful in training and injury prevention approach with young athletes.

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LATERAL DIFFERENCES IN MAXIMAL GRIP STRENGTH IN CZECH MALE TENNIS PLAYERS AGED 9–10 IN THE CONTEXT OF INJURY PREVENTION

Kolínský Roman, Strašilová Kateřina, Vodička Tomáš, Zháněl Jiří
Faculty of Sport Studies, Masaryk University Brno

Abstract

The term laterality refers to the side preference or dominance of a human body and its asymmetry. In the preference process, more accurate, precise, coordinated and stronger side is chosen from the perspective of motoric functions. In the general population, a left-handed preference ranging between 10-13% has been found. The percentage is higher in certain sport fields (soccer, tennis, volleyball etc.). The left-handed dominance in tennis is considered an advantage. The ratio of left-handed players is 16% among the world elite tennis players (TOP 100 ATP Rankings 2017). Due to unilateral load, there may be an excessive side-effect in strength differences in tennis and overloading of specific muscle group could lead to an injury. The aim of the research was to identify the levels of somatic and strength characteristics and assess the lateral difference in maximal grip strength of Czech elite tennis players. The sample consisted of tennis players, ranging in age from 9 to 10.9 years (n=85) who participated in the regular tests for Czech Tennis Association in years 2000-2015. Base anthropometricswere measured (height, weight) and maximal grip strength of both hands using the hand-held dynamometry (Grip D, Takei). It has been statistically proven (chi-square test) that the testing data come from normal distribution. The basic statistical characteristics were calculated (body height, M=144.93±5.97 cm; body weight, M=35.89±4.51 kg; strength of right hand: M=19.81±3.14kp; strength of left hand: M=17.30±3.35 kp). It was found that 93% of the players (n=79) used the right hand as their playing (dominant) hand and the remaining 7% used their left hand (n=6).The assessment of the significance (Cohen´s d) of the differences between the strength of the dominant (playing) hand of the right-handed and the left-handed showed large effect size (dominant hand right: M_{RHR}=19.80±3.12 kp, dominant hand left: M_{LHL}=23.00±3.05 kp; d=0.99, large) in favor of the left-handed players. The difference in strength levels between dominant (playing) and the non-dominant hand of the tennis players showed large effect size for the right-handed (dominant hand right vs. hand left; M_{RHR}=19.80±3.12kp, M_{RHL}=16.90±2.95 kp, d=0.96, large) and the left-handed (dominant hand left vs. hand right; M_{LHL}=23.00±3.05 kp, M_{LHR}= 19.40±3.39 kp, d=1.06, large). The results showed that significant number of players exceeds the 15% level of strength laterality between dominant and non-dominant hand (right-handed players: 43.04%, left-handed players 66.67%).In the sample, the rate of right-handed players was significantly higher (93% vs. 7%) which is lower than the elite adult players. The large effect size in levels of maximum strength of left-handed players and maximum strength of dominant hand was found. High percentage of players is exceeding the level of 15% difference of strength between dominant and non-dominant hand which can be a cause of injuries, therefore attention should be given during training.

Key words: *bilateral asymmetry, laterality, tennis, dynamometer*

Introduction

Human laterality research has a relatively long history. Generally, the term laterality refers to the one-sided preference of a body (upper and lower limbs, eyesight, hearing etc.), but also to the primary use of a brain hemisphere (Loffing et al., 2014). Sovák (1962) defines laterality as a developmental deviation in the meaning of superiority of one side over another; divides laterality into the functional (difference in paired motoric and sensory organs efficiency) and morphological (related to the asymmetry of body composition – shape, size and volume of paired organs, eventually of both parts of non-paired organs). Laterality is dependent on the performance of the movement center in the opposite hemisphere. The peripheral neuromuscular system of one side is controlled by cortex center of the opposite hemisphere, frequent use leads to economic and improved feedback between cortical center and executive organ (Bisiachi, 1985). Měkota (1986) distinguishes lateral preference (giving preference to one side of the body during life; movement certainty and accuracy) and dominance (apparent differences and superiority in the performance of one of the paired organs). The above-mentioned authors use the terms handedness, footedness, eyedness, earedness and rotation in relation to laterality manifestations. From the point of view of the research intention, we will focus on the handedness issue, which is the most studied area of laterality (hand using and preferring). Basic terms are right-handedness (dextrality), left-handedness (sinistrality) respectively. Ambivalent sidedness is called ambidexterity. Side preference may not necessarily be consistent for all tasks. There are individuals writing with their right hand but other tasks (e.g. playing tennis, kicking ball) with their left side. In that case, we are speaking about cross-dominance, i.e. preferring the motor skills manifestations for various tasks (Porac & Coren, 1981; Salmaso & Longoni, 1985, Měkota, 1986). In the general population, a left-handed preference ranging between 10-13 % has been found (Faurie & Raymond, 2004; Raymond et al., 1996). Representation of the left-handers may vary across different sports field, which is evidenced by studies (Grouios, 2004; Grouios et al., 2000; Hagemann, 2009; Raymond et al., 1996) describing higher representation of left-handers in interactive sports (e.g. tennis). Bisiachi et al. (1985) describes the ratio of left-handers approximately 15 % in tennis and the statistics are even higher among the world elite tennis players (16 % according to the TOP 100 ATP Rankings in 2017). Holtzen (2000), while analyzing the world rankings of tennis players from 1968 to 1999, found the representation of the left-handers corresponding to the population for all players – men (6.98 %) and women (7.69 %), but the percentage of left-handers among elite players was significantly higher (TOP 10 – 24.06 % for men, 11.80 % for women; the best world players – 34.3 % for men, 30.3 % for women; Grand Slam finalists – 22.27 % men, 18.75 % women). Higher percentage of left-handers also occurs in other sports (e.g. fencing, box, baseball, cricket and ice-hockey). According to Holtzen, Breznik (2013) also reported excessive representation in tennis and focused on the difference in gender representation. Men and women have different patterns of hemisphere specialization for cognitive functions that may be associated with sidedness; men performance within the visually-spatial capacity appears to be significantly higher compared to women (Singh & Singh, 2003), and points to a higher level of brain lateralization indicating that left-hand effect also depends on gender (Vogel et. al, 2003; Rilea et al., 2004). According to Geschwind and Galaburd (1987) and Wood and Aggleton (1989), left-hand population generally have a better overall spatial orientation, motor and attention functions. Faurie and Raymond (2004) and Raymond et al. (1996) argue that the disadvantage of the right-handers lies in the lack of experience of playing against left-handers, because statistically the rival is mostly right-handed. Players are therefore used to the playing style and strategy of right-handers, and the attack from the other side of the court can reach them unprepared (Coren, 1993; Grouios, 2004; Hagemann, 2009; Raymond et al., 1996). In a game with a left-hander they have to become accustomed to the change of usual strategy and, if he does not have a sufficiently automated defensive reaction, then this game is less effective (Breznik, 2013, Hagemann, 2009; Loffing et al. 2014; Wood & Aggleton, 1989). According to Grouios (2004) and Loffing et al. (2014), considering motor skills, the left-handers can benefit from weaker lateralization of the brain hemispheres for tasks using both hands. If we take into consideration the surface on which it is played, the left-handers should have an advantage on a faster surface such as grass or concrete (Fernandez et al., 2006; Breznik, 2013). Barnett et al. (2006) claims that rallies are shorter and players do not have enough time to adapt to the play style or readability against the slower surface (clay). Tennis is a game of limited number of motoric activities that are repeatedly performed. A frequent repetition of playing activities leads to a strength and flexibility imbalances which can lead to injury. Muscle dysbalances are created within the training and play load in tennis, so the player usually has stronger muscles on his dominant side. Motoric activities are parts of the kinetic chain, individual motions and strokes are generated from the legs and transfer through the trunk into arms and then into the racket itself. If it interrupts or weakens the chain, it will be replaced by other muscles that have to withstand abnormal load (Riewald & Ellenbecker, 2005). In tennis, injuries to the upper limbs are most often caused by the repeated excessive load of the speed-strength movement character. Repeated movement activities require an acceleration of the movement of the arms to generate a sufficient strength level and later slow down the swing during the stroke phase. It is therefore important to maintain optimal flexibility and muscle balance as well as the development of strength and endurance during the training process for injury prevention and performance optimization (Ellenbecker, 1997). According to Ellenbecker (1997, 2002) this movement limitation begins already with junior players between the ages of 11 and 12, and with the aging there is a progression that can limit the length of active career. Current elite tennis is characterized by faster and more powerful strokes, which puts much greater demands on conditioning of players. The arm muscles work both concentrically to provide enough strength for various strokes, and eccentrically so that the strength can then brake the ongoing arm swing (Roetert & Kovacs, 2011). One of the last segments of the kinetic chain in a serve or stroke is the elbow extension which is caused by triceps contraction which transfers the force from the trunk and upper arm into the racket. It should be noted that it depends on the grip and forearm strength, but also on the muscular endurance (with regard to the length of the match). It can be stated that optimal level of grip and forearm strength allows eliminating the overload of wrist, elbow and shoulder joints (Roetert & Kovacs, 2011). It is therefore obvious that strength has an important role in tennis. Due to repeated long-term activities, lateral strength differences can occur, which may be the cause of injuries, especially in the area of wrist, elbow and shoulder.

Methods

The aim of the study was to assess the lateral difference in maximal grip strength in Czech tennis players with regard to a possible risk of injury. The sample consisted of tennis players, ranging in age from 9 to 10.9 years (n=85, height M=144.93±5.97 cm andweight M=35.89 ±4.51 kg), who participated in the regular tests for Czech Tennis Association in years 2000-2015. The TENDIAG 1 testing battery, resp.3 out of 9 research-related partswas used: base anthropometrics (height, weight) and maximal hand grip strength using the hand-held dynamometry (Grip D, Takei, Japan, kp).The playing (dominant) hand was queried with each player. Each subject carried out two attempts for each hand in the standing position without touching the body, wrist in the neutral position and elbow extended. The result was the highest strength score and recorded as peak grip strength (kp). Research data were processed using STATISTICA 12 and Microsoft Excel software.The aim of the research was to (1) identify the levels of somatic and strength characteristics, 2) the rate of righ-handed and left-handed players, (3) lateral differences in grip strength between the dominant and non-dominant hand.

Results

It has been statistically proven (chi-square test, variations on goodness-of-fit) that the testing data come from a normal distribution. It was found that 93% of the players (n=79) were right-handedand the remaining 7% left-handed (n=6). Data analysis results: base statistical and anthropometric characteristics, maximal hand grip strength for the left and the right hand are presented in Table 1.

Table 1. Basic statistical characteristics of the sample

Sample	Tenists (n=85)			
Variables	M	SD	min	max
Age	10.24	0.49	9.00	10.90
Height (cm)	144.93	5.97	131.00	163.00
Weight (kg)	35.89	4.51	25.20	48.00
SR (kp)	19.81	3.14	11.90	26.00
SL (kp)	17.30	3.35	10.90	27.10

Legend: SR…max. strength right hand, SL… max. strength left hand, M… mean, SD… standard deviation

Table 1 shows that the mean value of the maximal strength for the right hand (SR = 19.81 kp) is higher than the left-hand (SL = 17.3 kp). It was verified that significance (Cohen´s d) for the difference in the mean strength values (2.51 kp) of both hands showed medium effect size (d=0.78, medium). This difference may be due to the fact that 93 % of players using their right hand as their dominant hand, while left-handers only by 7 %.

In Table 2, the average percentage diference between the maximum left and right hand strength is 15.15% of the 85 watched players, among 38 of them (44.71%) the strength diference between the dominant and non-dominant hand was found higher than 15%, with a diference greater than 20% being found in 20 (23.53%) players.

Table 2. Strength difference between the right and left hand

Difference	n	%
$D_{(R/L)}$	79 vs 6	15.15
>15 %	38	44.71
>20 %	20	23.53

Legend: $D_{(R/L)}$... difference between right and left hand,>15 %...strength difference greater than 15 %, >20 %...strength difference greater than 20 %

Players who use left hand as their dominant play hand have a greater maximal strength in both hands (dominant, non-dominant) compared to their right-handed rivals in Table 3.

Both player groups achieved relatively high strength differences between dominant and non-dominant hand, namely 43.04 % of the right-handed players and 66.67% of the left-handed players exceeded 15 % level of strength laterality.

Table 3. Maximal strength and differences between dominant and non-dominant hand

Variables	M strength	SD	Min strength	max strength	$D_{(R/L)}$> 15 %
RHR	19.80	3.12	11.90	26.00	43.04
RHL	16.90	2.95	10.90	25.50	
LHR	19.40	3.39	14.50	23.50	66.67
LHL	23.00	3.05	18.40	27.10	

Legend: RHR… dominant hand right - right hand, RHL… dominant hand right - left hand, LHR… dominant hand left - right hand, LHL… dominant hand left - left hand, M strength… mean strength, SD… strength standard deviation, , $D_{(R/L)}$... strength difference between R and L hand higher than 15 %

Data analysis results focused on assessingthe strength of the right-handed (RH) and the left-handed (LH) players (Table 3) showed large effect size differences (RH) vs. (LH) players (dominant hand right: M_{RHR}=19.80±3.12 kp, dominant hand left: M_{LHL}=23.00±3.05 kp; d=0.99, large) in favor of the left-handed players.The assessment of the significance ofthe differences betweenthe dominant (DH) and non-dominant (NDH) hand strength for the right-handed players showed large effect size in favor of the right hand (M_{RHR}=19.80±3.12 kp, M_{RHL}=16.90±2.95 kp, d=0.96, large) in Table 3. Also for the left-handed players significant difference was found between

(DH) and (NDH) hand strength (M_{LHR}=19.40±3.39 kp, M_{LHL}=23.00±3.05 kp, d=1.06, large) in favor of the left hand.

Discussion

The results of Häger-Ross & Rösblad (2002) showed no significant difference in grip strength between the genders until the age of 10 in general population. After this age the boys (n=267; 90 % right-handed, 10% left-handed) were significantly stronger than the girls with a steeper increase in their grip strength. Measured values at 9 years (13.96kp±2.65 a 13.66kp±2.78) and 10 years (17.04kp±2.78 a 16.90kp±2.87) were lower compared to our sample. The apparent drop in the maximal strength during repeated measurements occurred among the ages of 13-16. Below 12 years these drops did not appear, which could be the result of an incomplete maximal strength. The younger individuals were able to repeat relatively stable attempts, while older ones made much more effort and thereafter the maximal value fell. Approx. 80 % of the right-handed subjects were stronger in their dominant hand, while 60 % of the left-handed produced more strength with their non-dominant hand. Boys were, on average, 10% stronger on the right hand than on the left hand, which was consistent with oftencited “10% rule” for the lateral difference in the adult population. Later it was shown to be valid only for right-handed individuals. Results for left-handed people indicated that they were almost even without significant differences. Hepping et al. (2015) tried to determine the effect of hand preference on grip strength. They also tried to refute or confirm the “10% rule” for the left-preffered and right-preffered hand in boys (n=1130) of which 15.9 % preffered the left hand. Children preferring their right hand were stronger on the right hand in all age categories (9 years LH 16.7±3.8/ RH 18.3±3.7; 10 years LH 17.7±3.2/ RH 19.5±3.6; kp), whereas the left-handed were slightly stronger with their right hand in some categories with no significant differences (9 years LH 17.2±2.9 / RH 17.9±4.1; 10 years LH 19.7±2.8 / RH 19.6±3.4; kp). The results have shown that the “10% rule” of the dominant hand regarding the grip strength in adults can be also applied to children preferring right hand. However, this statement cannot be generalized for left preffered children because of more balanced results. In some cases, the non-dominant hand was even stronger → possible psycho-social pressure on left-handers to become ambidextrous or right-handed (the everyday needs tailored for right-handers). Incel et al. (2002) showed in their study that dominant left-handers were frequently stronger with their non-dominant (right) hand compared withtheir dominant (left) hand in adulthood as right-handed adults, 33.3 % vs. 10.9 % respectively. Peterson et al. (1989) found even a greater proportional difference → 48 % vs. 6.9 %. This was not investigated in children, but according to Incel et al. (2002) it may seemed that these differences remain relatively stable from childhood into adulthood. Ploegmakers et al. (2013) suggested that grip strength in boys (n=1112) grew almost linearly with age in both hands until the 12th year when showed accelerated increase in strength for dominant hand. In non-dominant hand we could observed similar tendencies after reaching the 13th year. They measured relatively the same values as in our research at the age 9 (DH-18.2±4, NDH-16.8±4;kp) and 10 (DH-19.6±2, NDH-18.1±3;kp) years.

Conclusion

Within the research of our sample, it was found that out of the total of 85 players 79 were righ-handed and 6 left-handed, 93 % vs. 7 % respectively. Among the observed players, there were found significant differences between the strength level of dominant (play) and non-dominant hand in both groups (right-handed and left-handed). There were also significant differences between the strength of the dominant right hand and the dominant left hand in favor of left-handed players. The mean difference in maximal right and left hand strength was 15.15%. Players who use their left hand as their play hand had a higher maximal strength in their dominant and non-dominant hand compared to right hand players where the right was stronger. Within the 15 % level of strength laterality difference, the value was exceeded for right-handed players (43.04 %) and left-handed players (66.67 %), which could be a cause of injuries or disbalances, therefore more attention should be paidto this issue during training (by coaches and players themselves).

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ONE WAY PROCEEDING OF LEARNING BASIC GYMNASTIC ELEMENTS

Milčić Lucija[1], Živčić Marković Kamenka[1], Aleksić-Veljković Aleksandra[2]
[1]University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia
[2]University of Niš, Faculty of Sport and Physical Education, Niš, Serbia

Abstract

The aim of this manuscript was to determine the difference between initial and final stage of basic acrobatic elements: forward roll, backward roll, piked backward roll, shoulder stand, cartwheel in left and right side and handstand. The research was conducted on a sample of 101 regular students of second year of the Faculty of Kinesiology, University of Zagreb. Initial test of motor skills was performed before listening the artistic gymnastics, and finally, after three months proceeding of learning. The evaluation of the performance technique was performed by three gymnastics experts. Differences between the initial and the final stage were determined by the t-test for independent samples with Levene's test. The obtained results show that in all tests of motor knowledge, students improved grades with statistical significance $p < 0.05$. Statistical 12 was used for data analysis. The results of this study indicate that the methodological learning process has significantly contributed to improving the performance of basic acrobatic elements. Therefore, the application of particular teaching methods can be applied to the beginner population.

***Key words**: artistic gymnastics, basic elements, teaching methods, learning*

Introduction

Basic acrobatic elements are a part of artistic gymnastics, which can be useful in the physical preparation in other sports. Rolls, handstands and handsprings are elements which are taught in primary schools, so they can later be upgraded into more complicated variants, on other gymnastics apparatus. Gymnastics elements are in the curriculum of primary schools (Vican & Milanović Litre, 2006). Application of these elements is versatile, from adopting regular exercising habits and positive influence on health, to apply in everyday life (Živčić Marković & Krističević, 2016). Based on experience, it was observed that students have bad knowledge of basic acrobatic elements. Seeing that it is predicted by plan and program to implement these elements during elementary school education, it is evident that the learning process and lack of material conditions in schools are greatly contributing to previously stated condition (Badić, Živčić Marković, Sporiš, Milanović, Trajković, 2012). In the study of Možnik, Krističević, Milčić, Živčić Marković, Šolja, 2017, it was established that the level of motor knowledge acquired before the beginning of the course Artistic Gymnastics was low, and it was assumed that this was due to inadequate use of gymnastics motor skills in schools. This situation is not just isolated to schools in Croatia. Only 40% of the content of gymnastics prescribed by the plan and program is being implemented by teachers in schools in Slovenia (Bučar Pajek, Čuk, Kovač, Jakše, 2010). There is a lack of research which examines the level of motor knowledge. Raising awareness of physical exercise and the influence it has on health, starting from pre-school, has been getting more attention lately. Kids should learn basic acrobatic elements through primary school, which will later be upgraded and used in everyday life. Many authors (Benn, Benn, Maude, 2007; Broomfied, 2011; Mitchell, Davis, Lopez, 2002.), state that teaching methods are important in progression of learning gymnastics elements. Methods of learning basic acrobatic elements consist of specific methodical exercises for successful learning of elements. Knowledge about order of learning of elements is necessary. The learning process starts with acrobatic elements through gradual adaptation to other gymnastics apparatus. First, students perform preparatory exercises, which improve motor abilities for successful execution the element. After preparatory exercises, students start performing pre–exercises progressively, which are a base for learning a larger number of gymnastics elements (from related structural groups). That way students acquire the fundamentals for an easier and more successful learning of acrobatic elements. The best age for learning basic acrobatic elements such as rolls, shoulder stands (candlestick), handstands and cartwheel is in primary school, before puberty, because in that period children are shorter and lighter and they can perform gymnastics elements more easily. It is much easier to properly assist children in primary school during learning and execution of gymnastics elements. On practical lectures of the course of Artistic Gymnastics, much attention is dedicated to the learning of basic gymnastic elements. Lecture topics are carefully elaborated, paying attention to the correct order of adoption of certain gymnastic elements; starting with acrobatic and progressively adding other elements on other apparatus. Similar techniques are combined, based on movement of body parts and body and types of rotation of the body around longitudinal or transversal axis of the body. What is executed and taught through acrobatic elements is also taught on apparatus through positions of supports and body hang. Reason for this is age of students and their weak motor knowledge of artistic gymnastics (Živčić Marković, Stibilj-Batinić, Gorišek, Šinkovec, 2011; Živčić Marković, Sporiš, Čavar, 2011; Možnik et al., 2017). With previous studies on examination of student motor knowledge in mind, it should be determined if implementation of existing curriculum of the course of Artistic Gymnastics has any influence on progress of learning basic gymnastic elements that students should successfully master.

The aim of this study was to determine the difference between initial and final motor knowledge between basic acrobatic elements after three months proceeding of learning: forward and backward roll, piked backward roll, shoulder stand, cartwheel on left and right side and handstand.

Methods

Research was conducted on a sample of 101 2^{nd} year students, 78 males and 23 females (19-20 years of age), of the Faculty of Kinesiology, with no previous experience in learning of basic acrobatic elements. Variable samples were basic acrobatic elements: FORWR_I was used for forward roll at the beginning of lectures and variable FORWR_F for forward roll after three months, BCKWR_I was used for backward roll at the beginning of lectures and variable BCKWR_F for backward roll after three months, BCKRSL_I was used for piked backward roll at the beginning of lectures and variable BCKRSL_F for piked backward roll after three months, CNDS_I was used for shoulder stand (candlestick) at the beginning of the lectures and variable CNDS_F was used for shoulder stand after three months, CHRTWL_I was used for cartwheel on the left side at the beginning of lectures and variable CHRTWL_F for cartwheel on the left side after three months, CHRTWR_I was used for cartwheel on the right side at the beginning of lectures and variable CHRTWR_F for cartwheel on the right side after three months, HST_I was used for handstand at the beginning of lectures and variable HST_F handstand after three months. Examination of these elements was done by three gymnastics experts who evaluated them, with grades from 1 to 5. Grade one presented the worst performance and grade five the best performance, Table 1. Živčić Marković & Breslauer, 2011).

Table 1. Structure of assessment of gymnastic elements

Grade	Gymnastics elements
Exellent (5)	the task is performed, dynamically, fluently, and with no errors in execution
Very good (4)	smaller errors in performance
Good (3)	the performance is not dynamic, safe, and has more errors in all phases of performance
Sufficient (2)	very insecure with large errors at all phases of performance
Insufficient (1)	the performance does not look like the default element

Measurements were conducted at the beginning of the course of Artistic Gymnastics and after a period of three months. Students participated in the process of learning of basic acrobatic elements through specific teaching methods, Figure 1 to 6. (Živčić Marković & Krističević, 2016). Basic acrobatic elements were the first lessons in the plan and program of Artistic gymnastics I and students participated in

26 (90 min) class of learning basic acrobatic elements throughout the period of three months, twice per week. Each class was composed of classic gymnastics warming up (45 min), after that, students pass through exercises in order that are shown in Figures. Each element was explained and shown by the professor and gymnast. Performance feedback like didactical procedure were consisted of correcting mistakes by a professor and assistance in performance.

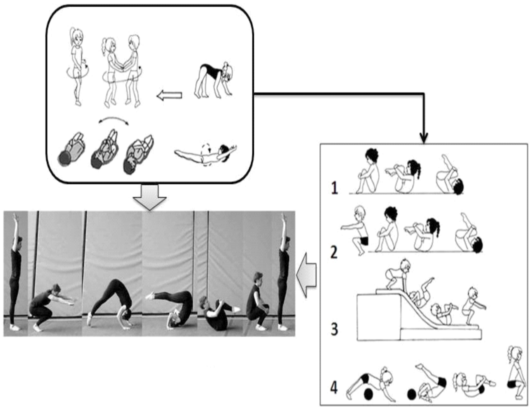

Figure 1. Methodical exercises for forward roll

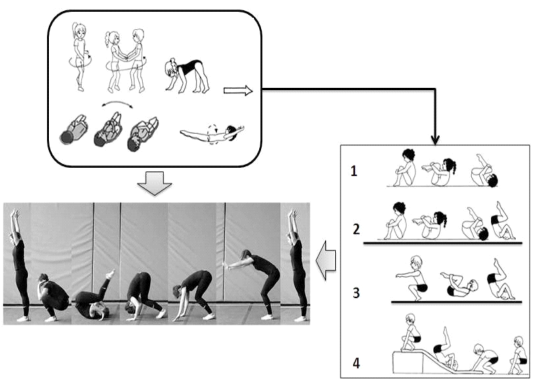

Figure 2. Methodical exercises for backward roll

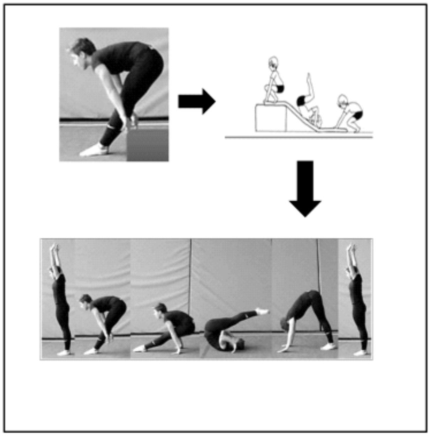

Figure 3. Methodical exercises for piked backward roll

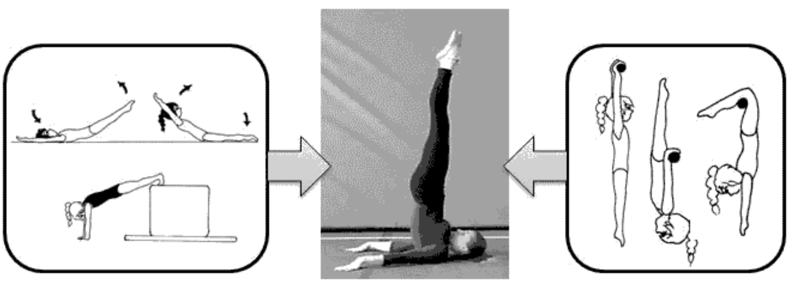

Figure 4. Methodical exercises for shoulder stand

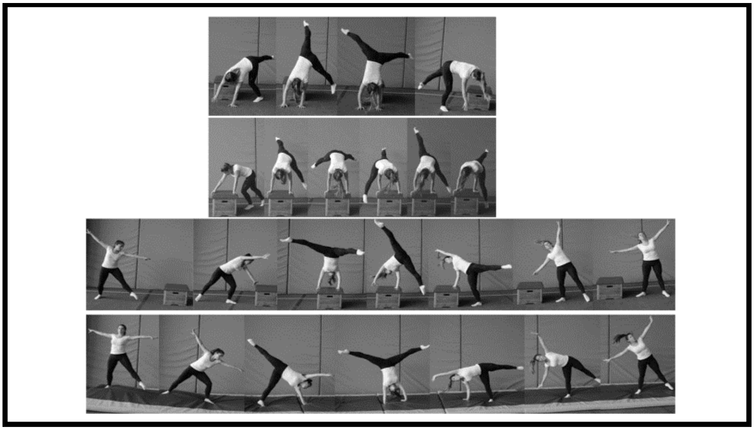

Figure 5. Methodical exercise for cartwheel

Figure 6. Methodical exercises for handstand

Statistica 12 was used for data analysis. Basic descriptive parameters and t-test for dependent samples were calculated for differences between the initial and final stage of treatments with Levene´s test for homogeneity of the variance, with statistical significance of $p < 0.05$.

Results

Basic descriptive parameters of measured variables are shown in Table 2. Average values of initial knowledge of all basic acrobatic elements ranged from 1,91 (CNDS_I) to 2,44 (HST_I) which represents very low knowledge. Minimal values for all elements were 1,00 and maximal were 5,00, while BCKWR_I, CNDS_I, and HST_I maximal values were <5,00 (4,67). In the final measurement, average value was from 3,38 (HST_F) to 4,27 (CNDS_F), while minimal value was 2,00 and maximal 5,00 in all measured variables.

Table 2. Descriptive indicators

Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
FORWR_I	101	2,42	1,00	5,00	1,11
FORWR_F	101	4,15	2,00	5,00	0,80
BCKWR_I	101	2,37	1,00	4,67	1,05
BCKWR_F	101	4,17	2,00	5,00	0,86
BCKRSL_I	101	2,13	1,00	5,00	1,13
BCKRSL_F	101	4,38	2,00	5,00	0,73
CNDS_I	101	1,97	1,00	4,67	0,97
CNDS_F	101	4,27	2,00	5,00	0,73
CHRTWR_I	101	2,34	1,00	5,00	1,15
CHRTWR_F	101	3,86	2,00	5,00	0,91
CHRTWL_I	101	2,25	1,00	5,00	1,12
CHRTWL_F	101	3,75	2,00	5,00	0,94
HST_I	101	2,44	1,00	4,67	1,04
HST_F	101	3,38	2,00	5,00	0,99

Results of t-test for dependent samples are shown in Table 3. Significant progress ($p= 0.00$) was recorded in all measured variables. Students have shown most progress in variable CNDS_F by up to 2.29 increase in grade, and least in HST_F (0.94). In other variables, the average improvement was from 1.50 to 2.25 increase in grades.

Table 3. T-test for dependent samples

Variable	Mean	Std.Dv.	N	Diff.	Std.Dv. Diff.	t	df	p	Conid. -95,0%	Confid. +95,0%	Levene F(1,df)	df Levene	p Levene
FORWR_I	2,42	1,11											
FORWR_F	4,15	0,80	101	-1,73	1,11	-16,0	100	0,00	-1,95	-1,51	16,1	200	0,00
BCKWR_I	2,37	1,05											
BCKWR_F	4,17	0,86	101	-1,80	1,15	-16,0	100	0,00	-2,03	-1,57	4,07	200	0,05
BCKRSL_I	2,13	1,13											
BCKRSL_F	4,38	0,73	101	-2,25	1,17	-19,0	100	0,00	-2,48	-2,02	22,9	200	0,00
CNDS_I	1,97	0,97											
CNDS_F	4,27	0,73	101	-2,29	1,04	-22,2	100	0,0	-2,50	-2,09	6,75	200	0,01
CHRTWR_I	2,34	1,15											
CHRTWR_F	3,86	0,91	101	-1,52	1,17	-13,0	100	0,00	-1,75	-1,29	11,0	200	0,00
CHRTWL_I	2,25	1,12											
CHRTWL_F	3,75	0,94	101	-1,50	1,14	-13,0	100	0,00	-1,72	-1,27	6,36	200	0,01
HST_I	2,44	1,04											
HST_F	3,38	0,99	101	-0,94	1,25	-7,5	100	0,00	-1,18	-0,69	0,03	200	0,86

Discussion

Biggest progress was observed in CNDS_F, for 2.29 grades, which can be prescribed to the fact that students had a very low level of knowledge of that element in the beginning. Shoulder stand should be taught in the second grade of primary school and during lectures in college Artistic Gymnastics, it is taught as a second teaching unit (of 15 planned). Since the initial average value was very low (1.97) for this type of a simple gymnastics element, it can be assumed that participants are not met with this type of movement during the primary school. The shoulder stand belongs to basic acrobatic elements from the group of holds, and it can be concluded that students have quickly learned this technique, despite the previously non-existent experience, because of simplicity of the element. Also, as teaching shoulder stand has started at the very beginning of the lectures, students had sufficient time to fully adopt the technique. In the college curriculum, shoulder stand is taught in parallel with straight inverted hang on parallel bars and rings (this is not the case in schools). This additionally influences required static strength of the trunk which helps with performance of shoulder stand, since the surface of the support of the body is significantly wider (upper body, neck and head, support through full arm length on the back of the body) than in straight inverted hang (Krističević, Živčić Marković, Fišter, Milčić, 2015). Piked backward role is second in level of adoption with progress of 2.25 in grade. This element is not taught in schools as a separate teaching unit, because basic rolls with bent trunk are a basic that should be learned in primary schools. Since the knowledge acquired beforehand was extremely low- (2,13) it is understandable that there was a significant progress. It can assume that methodical proceedings of learning and hierarchical methodical preparatory and pre-exercises methodology of the whole group of elements (rolls) (Živčić Marković, Krističević, Milčić, Fišter, 2015) enabled a more successful adoption of techniques. Results have shown weaker average grades of initial knowledge of FORWR_I (2.42) and BCKWR_I (2.37), CHRTWR_I (2.34) and CHRTWL_I (2.25) and HST_I (2.44). A previous study has shown that students of the 2nd year of the Faculty of Kinesiology in Zagreb have weak motor knowledge before the start of lectures and exercises of Artistic Gymnastics (Živčić Marković et al., 2011, Možnik et al., 2017). Živčić Marković et al., (2011) state that second-year students of the Faculty of Kinesiology did not gain practical information about fundamental gymnastics movement skills during their primary school, and that their knowledge of artistic gymnastics is at an insufficient level, based on the eight fundamental gymnastics movement structures (forward roll, backward roll, right cartwheel, left cartwheel, handstand, pullover, forward walk on the balance beam and safety walk on the balance beam). After the completed methodical proceeding of learning process during the lectures and supplementary exercises, average scores were statistically significantly higher (FORWR_F, 4.15, BCKWR_F, 4.17, CHRTWR_F at 3.86, and CHRTWL_F to 3.75, and HST_F 3,38). These acrobatic elements are taught during the first five units within the course of Artistic Gymnastics. Along with fundamental techniques, additional variant is taught, which serve to master the techniques more easily along with fundamental techniques. They enable additional development of specific motor skills and thus contribute to improvement of technique of execution of basic and other, more complex acrobatic and gymnastic elements. Hierarchical methodical scale of learning in artistic gymnastics is systematically and empirically thoroughly developed (Novak, Kovač & Čuk, 2008; Živčić & Krističević, 2016), and enables the addition of more complex structures according to the didactic principle - from simple to complex.

Conclusion

Artistic gymnastics, along with athletics and swimming, is one of the oldest basic sports. This can also be seen from the plan and program of physical and health education that is predicted by the curriculum for primary schools (MZOŠ, 2006). From a total of 205 teaching themes from first to eighth grade, 38% of the content belongs artistic gymnastics (Živčić Marković, 2010; Živčić Marković & Krističević, 2016). Therefore, lack of knowledge of basic acrobatics, defined by forward and backward rolls, shoulder stand, cartwheel and handstand along a vertical surface, is very alarming and raises a number of questions. Through examination of motor skills of 2nd year students of the Faculty of Kinesiology in Zagreb before and after the implementation of the Artistic Gymnastics lectures, results have shown an improvement in all tests for motor skills. Results of this study indicate that methodical proceeding of learning significantly contributed to improvement in performance of basic acrobatic elements. Therefore, application of individual exercises that make methodical proceeding of learning basic acrobatic elements, can be applied to beginner student population.

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COMPARISON OF RESPONSE CAPABILITIES AMONG STUDENTS OF SPECIAL EDUCATION OF SECURITY BODIES STUDY PROGRAMME, COMBAT SPORTS ATHLETES AND PHYSICALLY INACTIVE PERSONS

Novák Jan, Vít Michal, Puda Dominik
Faculty of Sport Studies, Masaryk University, Brno, Czech Republic

Abstract

*Purpose***:** The aim of the study was to determine the level of response capabilities among students of Special Education of Security Bodies study programme (SESB), physically inactive persons and to provide comparison with results of combat sports athletes based on literature research.

*Methods***:** Students of SESB were tested in June 2017 by the Vienna Testing System. The data were processed by the Vienna Testing System and followed by descriptive statistics using excel. Data interpretation was performed by comparing with available literature, especially with the available standards of the Vienna Testing System – results of normal population and the professional athletes of combat sports.

Reaction test (version S1) standards is based on a sample of 139 people of normal population (no significant differences between males and females or education level), the sample was divided only by age – 16-50 years (N = 67), over 50 years (N = 72) (Neuwirth, Benesch, & Hoskovcová, 2007).

According to the manual the main determinant test variable is the number of correct responses to the stimuli. Standards for Reaction test version S1 of the determination test are obtained on a sample of 1179 persons. They are normal adults whose data was collected between 1996-2001 (Neuwirth, Benesch, & Hoskovcová, 2007).

*Results***:** The mean reaction time for the reaction test was 261,20 ms. According to the standards of a representative sample SESB in the group the average percentile was 72.60 and compared with a standard based on the age of the average the result was 62.13 percentile. The average time for motor response SESB was 118.47 ms. The average percentile compared with a representative sample was 78.40 and compared with standards based on age was 61.73 percentile value.

For determination test, the number of correct answers for SESB reached the average of 251.13 and compared with the standard based on a representative sample the average percentile was 64.67. In comparison with the standard based on age the average percentile was 39.20.

*Conclusions***:** In reaction test the average reaction time differed only in values between 10ms between tested groups. Group “medal taekwon-do” achieved the best results. Time average and motor reactions differed only in the range 10ms and SESB group achieved the best time.

In the determination test group "non-medal taekwon-do" achieved the highest average number of correct answers. Group SESB was second and group "medal tae-kwon-do" was third. Group SESB reached lower average median reaction time.

Key words: *Stress, Reaction time, Determination test, Reaction test, SESB, motoric reaction*

Introduction

Reaction ability as a one of a motor abilities affects motoric skills and performance. Self-defense situations are highly stressful actions demanding good level of response capabilities of attacked person. Not only reaction ability, but also anticipation are important predictors of successful solved conflict situation. The response capability is especially needed among disabled people (Cihounkova, Skotakova, Kohoutkova, & Bugala, 2016).

The study field Special Education of Security Bodies (SESB) aims at preparing qualified, university educated specialists in security services of a broad scope. Graduates will be prepared in theoretical subjects of jurisprudence, social, bio-medical, and kinesiology sciences. Graduates are prepared in combat sports, martial arts, and climbing, swimming, gymnastics, track and field and self-defense. They gain also communication skills to cope with conflict and extreme situations (Bugala, Reguli, & Čihounková, 2015; Reguli, Bugala, & Vít, 2016). Some studies confirmed influence of SESB study progamme not only on educational outcomes in the cognitive domain, but also in the psychomotor domain, e.g. on the correct body posture (Struhar, Dovrtelova, & Reguli, 2015). According to the specific composition of practical courses focusing on preparatory combatives, combat sports and self-defense we assume good level of response capabilities among SESB students.

The aim of the project about reaction time is to find out how different groups of athletes react to stress situations, attention deficit and reaction time for visual and acoustic stimuli. The ability to withstand the stresses in sport is one of the limiting factors of sport performance (Kalichová, 2013, Schmidt & Wrisberg, 2008, Pargman, 2006). Stress has an impact on decision-making and reaction time in both sports and self-defense situations (Siddle, B. & Siddle, K.). Sports (especially combat) and self-defense situations are close to a movement task - overcoming an opponent in which the role of a timely response to the attack plays a role. The ability to respond in stressful conditions should therefore be followed by the selection of different athletes and experts in the application of sporting skills.

Methods

Students of SESB were tested in June 2017 by the Vienna Testing System (VTS). The data were processed by the Vienna Testing System and followed by descriptive statistics using Microsoft Excel software. Data interpretation was performed by comparing with available literature, especially with the available standards of the Vienna Testing System - results of normal population and the professional athletes of combat sports.

The research group was composed of students of the 3rd year of the Bachelor's degree program in the Faculty of Sports Studies, namely the Special Education of Security Bodies (hereinafter referred to as SESB). The research group consists of 15 students (3 women, 12 men). The average proband age is 23.4 years. It is a deliberate choice for the comparison of SESB students with VTS standards, as well as the comparison with the results of the research carried out on athletes of diverse orientation.

The reaction test measures the response time to visual and auditory stimuli. It also focuses on the diagnosis of attention, the ability to suppress a wrong or inappropriate response, and also the level of alertness and focused attention (Neuwirth, Benesch, & Hoskovcová, 2007).

In the reaction test, optical stimuli (yellow, red, white light) appear on the monitor. Tones are presented through headphones (the frequency is around 2000 Hz). The person under test responds by pressing the black button on the reaction panel. Under this reaction button is a so-called "idle button", which is a round gold button. Measurement takes place by proband putting a finger on the idle button and then pressing the response button after registering the stimulus. After that, the finger must be put back on the idle button.

Testing of the reaction speed with the Vienna Testing System can be carried out in several variants (S1 - S8), where the variants differ for example by reacting to different stimuli - yellow, red and yellow in color, yellow color + tone, and others (Neuwirth, Benesch, & Hoskovcova, 2007). For the purpose of this research, the variant S1 was chosen - a simple reaction to the yellow color.

Reaction test (version S1) standards is based on a sample of 139 people of normal population (no significant differences between males and females or education level), the sample was divided only by age - 16-50 years (N = 67), over 50 years (N = 72) (Neuwirth, Benesch, & Hoskovcová, 2007).

The Determination Test is aimed at monitoring the respondent's responses in a stressful situation. The task of the person undergoing this test is to respond quickly and precisely to the sound and visual stimuli in the appropriate way - by pressing the button or pedal (Vienna Test System: Test Catalog). The test evaluates resistance to stress, response time and attention deficit (Neuwirth, Benesch, & Hoskovcová, 2007). This type of test was chosen to determine the resistance of probands to the effects of stress that the system artificially created in this type of test in a way that accelerated the input of stimuli, thereby shortening the maximum time for the choice of reaction mode and proband execution.

The duration of the test is between 6-15 minutes, including initial instruction and training.

A larger number of variants of the test is also available in the determinant test. For the purposes of this research, variant S1 is used. In this form, the proband responds to color stimuli by pressing the corresponding button on the panel (blue, yellow, red, white, green) along the audio signal by pressing the gray or black square button (gray = high tone, black = low tone). And when pedaling is indicated, depress the corresponding pedal (left, right). This test is in the so-called adaptive mode, ie the rate of input of the stimulus is governed by the probands rate (the speed is derived from the average of the last 8 reaction times). If the proband did not respond properly (by pressing the wrong button or pedal), the program chooses a double value instead of the calculated response time of the proband. This procedure should allow a fair grip of "reactive stress tolerance" (Neuwirth, Benesch, & Hoskovcova, 2007).

According to the manual the main determinant test variable is the number of correct responses to the stimuli. Standards for Reaction test version S1 of the determination test are obtained on a sample of 1179 persons. They are normal adults whose data was collected between 1996 - 2001 (Neuwirth, Benesch, & Hoskovcová, 2007).

Results

The result of the average percentile of the reaction time (261.20 ms) according to the standard "representative sample" n = 139, was at 72 percentile (72.60) for the SESB group and compared to the age-based standard (range 16-50 years) 67 was an average score of 62 percentile (62.13). The mean percentile for the motor reaction time, which averaged 118.47 ms for SESB, was 78.40 compared to a representative sample percentile and compared with a norm based on age, had a percentile of 61.73.

The number of correct responses to the determination test was 251 at an average of 251.13, and the average percentile was 64.67 compared to the norm based on the representative sample. In comparison with the age-based standard, the average percentile was SESB 39.20.

Table 1. Summary results of the reaction and determinations test

	Reaction test								Determination test											
The name of tested person	Average of motoric reaction	Percentile average motor response - standard representative sample	Percentile average motor response - standard age	Average of reaction time	Percentile of the reaction time average - standard representative sample	Percentile of reaction time average - age standard	The degree of scattering of the motor reaction time	Rate of reaction time scattering	Omitted	Percentile omitted - representative sample	Percentile omitted - age standard	Erroneously	Percentile erroneous - representative sample	Percentile erroneously - Standard Age	Median of reaction time	Delayed reaction	Correct	Percentile correct - representative sample	Percentile correct - age standard	Number of complaints
TP 1	97	91	82	217	97	92	32,10	18,42	15	32	36	37	6	8	0,68	64	276	83	69	297
TP 2	101	93	84	226	96	91	54,88	19,99	23	11	14	40	5	7	0,65	65	266	77	54	301
TP 3	111	80	56	229	96	91	16,69	36,26	20	18	21	22	15	26	0,71	52	260	73	46	288
TP 4	127	76	58	258	78	65	40,41	24,22	8	66	64	25	12	21	0,8	64	228	47	12	250
TP 5	89	93	85	210	99	99	10,02	26,90	22	13	17	16	27	43	0,75	48	235	52	21	264
TP 6	119	78	60	273	66	51	20,90	32,85	8	66	64	10	49	69	077	74	254	67	40	269
TP 7	142	62	33	311	35	20	21,75	31,68	12	44	43	8	59	78	0,7	73	279	85	73	296
TP 8	106	83	69	339	28	13	14,74	89,00	14	35	35	38	5	5	0,79	48	216	37	16	245
TP 9	199	41	13	277	59	44	91,48	26,44	17	26	26	25	12	21	069	51	259	72	46	290
TP 10	82	95	88	314	36	20	11,23	42,44	15	32	36	26	11	17	0,8	50	225	44	11	251
TP 11	156	54	24	263	77	64	36,16	50,25	21	16	16	32	8	6	0,71	55	246	60	35	279
TP 12	116	79	62	220	97	92	24,82	14,89	11	48	47	29	9	14	0,71	83	270	79	57	290
TP 13	123	83	69	277	66	51	65,92	33,41	12	44	43	17	24	41	077	66	253	66	37	271
TP 14	78	99	98	238	92	86	27,51	37,37	5	84	85	21	16	28	0,79	81	249	63	35	263
TP 15	131	69	45	266	67	53	20,94	18,02	12	44	43	13	37	53	0,76	66	251	65	36	268
Average	118,47	78,40	61,73	261,20	72,60	62,13			14,33	38,60	39,33	23,93	19,67	29,13	0,74	62,67	251,13	64,67	39,20	274,80
Standard Devergence	30,02	15,68	23,82	37,49	23,74	28,30			5,25	20,57	19,39	9,71	16,07	22,29		11,30	18,01	13,97	18,47	17,71
Median	116,00	80,00	62,00	263,00	77,00	64,00			14,00	35,00	36,00	25,00	12,00	21,00	0,75	64,00	253,00	66,00	37,00	271,00
Modus		93,00	69,00	277,00	97,00	92,00			12,00			25,00				64,00				290,00

Discussion

Gierczuk, Bujak, Rowiński, & Dmitriyev (2012) compared their level of motor skills with elite wrestlers and taekwonders. The number of people tested was 49 (including 25 wrestlers and 24 taekwonders). The average age for wrestlers was 21.9 years for taekwonders 22.7 years. The first group had a training experience of 7-14 years, the second group of 6-16 years. First comparation compare the values that were found in the reaction rate test of the athletes group of the above-mentioned research with those of the SESB test group.

From the values shown in the chart and chart, the elite level performers show better results in the visual response time test than the SESB test subjects.

Gierczuk, et.al. (2012) also used the DT-S1 determinant in their study, and therefore their results with the SESB group tested with the same test variant. Below is the comparison of the determination test.

Further studies on the issue of reaction time testing using VTS were the studies by Zwierko, Osiński, Lubiński, Czepita, & Florkiewicz, (2010). The main aim of the authors was to compare the results of the simple reaction rate, selective reaction rate, and peripheral perception test. The test included twelve men playing volleyball with an average age of 22.86 years and an average sporting experience of 9.37 years. The control group included 12 untrained male students with an average age of 21.9 years (Zwierko, Osiński, Lu-biński , Czepita, & Florkiewicz, 2010).

For this comparison, the result of the reaction time for a simple visual response will be given.

One study, which also used the RT-S1 reaction test and the DT-S1 determination test, was the study by Sadowski, Gierczuk, Miller, Cieśliński & Buszta (2012). The aim of the study was to identify the success factors of elite taekwondo players in the context of winning a medal during the Polish Junior Championships (Sadowski, Gierczuk, Miller, Cieśliński & Buszta, 2012).

Testing was attended by 63 taekwondo players whose age average was 15.91 years and their average training practice was 5.12 years. Tested persons were divided into two groups, the first group consisting of individuals who won the medal (n = 27) - "MW" (medal won), the second group consisting of probands (n = 36) 8th place - "NMW" (non-medal) (Sadowski, Gierc-zuk, Miller, Cieśliński & Buszta, 2012).

On the next comparison the mean values of the taekwondists with the average values obtained by the SESB probes are described.

The average reaction time varied only within 10ms between the groups studied, the best results achieved by the taekwondo medalists. The average motor reaction time varied only within 10ms, and the best time was achieved by SESB.

In the determinative test, the taekwondo group of "non-medailist" reached the highest average number of correct answers. The SESB group followed, followed by a group of taekwondo medalists. The lowest mean reaction time median was achieved by SESB.

The fact that SESB students are less successful in the reaction test compared to combat sports athletes can, in our view, be explained by the fact that the sum of the training units developing the reaction rate and the speed of motor reaction is usually higher for professional sports than for SESB students. On the contrary, we usually explain the higher success rate in the determinative test by the fact that SESB students have a larger variety of practical subjects - they are not narrowly specialized in one compulsive sport - and therefore better cope with a greater number of different stimuli.

It might be advisable to think about whether the reaction speed in the practice of combative sports has a different impact on the ability to react against non-ballistic sports, for example, when it plays a role such as self-preservation (strike > pain, injuries) compared to volleyball , when this factor is virtually eliminated. On the example of a comparison of SESB and volleyball players testing in the "Results" chapter, we can see that volleyball players have on average achieved better results than the "officers". However, only small samples of athletes were examined, and therefore this result cannot be generalized.

Conclusion

The research compared the level of responsiveness of SESB students with professional athletes of combative sports and non-sportsmen.

It has been confirmed that the level of reactivity is higher for SESB students than for the general population.

When comparing the results of the reaction and determinative test, it can generally be concluded that SESB students have achieved worse results than professional athletes of combat sports. On the other hand, it can be generally concluded that SESB students achieved better results in the determinative test compared to professional athletes of shock sports.

We assume that this research may be an appropriate initial outreach for ongoing research, especially for stress and related motor reactions in attacking individuals in defense. Its results can also be taken into account in the modification of combative sports training, personal and professional self-defense courses, as well as the innovation of SESB.

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ANALYSIS OF PEDAGOGICAL-MATERIAL STANDARD OF WATER SPORTS TEACHING

Oreb Bor, Prlenda Nikola, Oreb Goran
Faculty of Kinesiology,University of Zagreb (Zagreb, Croatia)

Abstract

Water sports are regular subject in the curricula of the Faculty of Kinesiology of the Zagreb University. It comprises four Olympic sports: sailing, windsurfing, rowing and kayaking. Through the analysis of results obtained by anonymous questionnaire researching pedagogical-material standard, it is the aim of this paper to contribute to the quality of Water sports teaching.

The research was conducted on the population of 2400questionnaire treated examinees, regular male and female students of the Kinesiology faculty of the University of Zagreb, between the age of 21 and 25, who attended Watersports classes in the period from year 2001 to 2015. The programs of sailing, windsurfing and kayaking were realized through field classes on Badija island – Korčula, in duration of 7 days, on a daily working regime of two lessons for every activity. At the end of the program, students have assessed, through anonymous questionnaire, 12 variables (traveling, accommodation, food, teachers, assistants, vessels, climate, curriculum, sailing, windsurfing, rowing and kayaking) on a five-degree Lickert scale.

Results showed that total arithmetic mean of all the variables in the mentioned period was 4.30, representing very high level of satisfaction of students through the whole period in all the variables. The lowest average assessment grade was noted in a variable Traveling (AS 3,23), and Rowing (AS 3,30), while the highest average grades were assigned in the variables Climate (AS 4,66) and Assistants (AS 4,59). Average results by years also show high average grade for all the assessed generations. The highest average grade was given by generations 2013 (AS 4,45) and2014 (AS 4,44), while the lowest average grade was assigned for generations 2001 (AS 3,53) and 2003 (AS 4,08).

Based on the obtained results it is concluded that student population in years 2001 to 2015 is extremely content with Water sports collegium as a whole.

Key words: *students, sailing, windsurfing, rowing, kayaking, teaching*

Introduction

Watersports are a regular subject on the Faculty of Kinesiology on the University of Zagreb. It consists of four Olympic sports- sailing, windsurfing, rowing and kayaking.

Since High School for physical culture was established in 1959, and later Faculty for physical culture (1973.), to Faculty of Kinesiology today, teachers are continuously in touch with world trends, adjusting constantly their teaching curricula. Unfortunately, although Croatia is Mediterranean country and should be as such oriented towards watersports, number of classes in this subject is reduced from 120 classes before to just 60 classes nowadays. Due to the reduced fund of classes, teachers and assistants are trying to compensate this evident lack of classes for as much as four Olympic sports through the organization of subject.

Organization of field classes includes transportation to the place where classes are held, accommodation, food, material-technical conditions and professionals to conduct the teaching process. With the aim of improving the quality of teaching, since 2001 anonymous questionnaire is carried out among the students, researching the level of satisfaction with the pedagogical – material standard of Watersports field teaching realization. By increasing of quality of organization and quality of material means, the aim is to satisfy needs and interests of students (Duplančić et al. 2008).The importance of getting feedback concerning the satisfaction with particular program is noticeable also in the results of possible impact on the attitude towards particular sport after finishing the teaching (Prlenda et al. 2017; Vlašićet al. 2012 and Cigrovski, et al. 2014).In addition, physical activity is closely connected to health improvement, so it is expected that through quality feedback and by adjusting of teaching to the current needs of attendants, an impact can be made improving life quality and illness prevention in attendants, ensuring through this safe learning of the new activity (Trudeau & Shephard, 2005).

The aim of this paper is to increase the quality of Watersports teaching organization based on the results acquired in the period from year 2001 to year 2015.

Methods

Examinees

The population of examinees in the period between years 2001 and 2015 was made of 2400 regular male and female students of the Faculty of Kinesiology of the University of Zagreb, in the age between 21 and 25 years.

Variables

After finishing the practical part of exam, students were completing anonymous questionnaire (Oreb, 2000) constructed with the aim of assessing pedagogical – material standard of the field classes of Watersports. The questionnaire consists of 12 variables assessed by students through grades from 1 to 5, 1 being very bad, 2 – bad, 3 – good, 4 – very good, and 5 – excelent.

Variables consist of questions assessing traveling, accommodation, food, teachers, assistants, vessels, curriculum, sailing, windsurfing, rowing, kayaking, and climate.

Program of practical classes of watersports

Practical part of rowing classes was held in Zagreb- in the rowing and on the rowing track on the Jarun lake, while sailing, windsurfing and kayaking classes are held as a part of the field classes in the Badija island aquatorium in the vicinity of Korčula island.

Teaching program was held in the duration of 7 days, and the last day was used for a practical part of the exam. In a one week program there were maximum of 45 students divided into 3 teaching groups consisting of 15 students. Basic programs of sailing, windsurfing and rowing (kayak – canoe) were realized through two lessons a day for every individual activity.

Basic program of sailing was conducted from year 2001 to year 2011 inclusive on Elan -19 sailing boats (5,80 m, four-seat), and from year 2012Scholtz 22 sailing boats (6,70m, five-seat) are used. On every boat, there was one teacher. Windsurfing was held under direct guidance of teachers and demonstrators, ashore using simulators, and on sea on the multiuse stabile boards with sails appropriate to the beginners and adjusted in size. For rowing (kayak – canoe) stabile turist „sit-on-top“type kayaks were used. There was a teacher leading every teaching group. Classes were held in period from 8.30 to 13.00 hours, and after students had a lunch at the hotel. Afternoon hours were used for practicing and acquiring of elements of technique for individual sports. The exam was held on the seventh day after morning classes and lunch break.

Statistical analysis

Arithmetic means of answers for all the examinees a generation, and specifically for every variable were calculated using *excel 2013*program.

Results

Table 1. shows average grades for variables in the period from 2001 to 2015 acquired through questionnaires. The lowest grades in the period from 2001 to 2015 were for variables Traveling (3,23), Kayaking (3,30) and Rowing (3,68),while the highest were for variables Climate (4,66), Assistants (4,59) and Food (4,57). Assessing the satisfaction of examinees for every generation for variables in question, the lowest grades were for the first assessed generation of 2001 and also in 2003 (4,08) and 2009 (4,19). Highest average grades were assigned by generations of 2013 (4,55),2014 (4,54) and 2012 (4,49).

Table 1. Average grades assessing the satisfaction of examinees in the period from 2001 to 2015

	2001	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2001-2015
Variable	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Traveling	2,51	2,98	2,43	2,53	2,97	3,31	3,53	3,19	3,20	3,30	3,40	3,96	4,11	3,81	**3,23**
Accommodation	2,58	3,64	4,71	4,41	4,56	4,36	4,39	3,74	3,93	4,25	4,17	4,16	4,35	4,00	**4,09**
Food	3,97	4,27	4,39	4,53	4,62	4,61	4,80	4,17	4,80	4,83	4,74	4,84	4,86	4,58	**4,57**
Teachers	3,69	4,24	4,52	4,68	4,42	4,49	4,58	4,50	4,79	4,64	4,70	4,73	4,65	4,57	**4,51**
Assistants	3,69	4,46	4,72	4,76	4,53	4,75	4,56	4,61	4,72	4,58	4,73	4,71	4,76	4,65	**4,59**
Vessels	3,83	4,19	4,31	4,40	4,54	4,33	4,68	4,38	4,72	4,61	4,86	4,80	4,78	4,58	**4,50**
Curriculum	3,37	4,19	4,43	4,59	4,32	4,31	4,64	4,36	4,72	4,46	4,69	4,70	4,65	4,45	**4,42**
Sailing	0,00	4,56	4,76	4,78	4,75	4,66	4,68	4,63	4,86	4,63	4,85	4,88	4,78	4,73	**4,40**
Windsurfing	0,00	4,59	4,56	4,87	4,76	4,48	4,81	4,61	4,88	4,67	4,79	4,94	4,80	4,62	**4,38**
Rowing	0,00	3,67	3,93	4,27	4,21	3,27	3,95	3,89	4,02	3,93	4,17	4,12	4,09	3,93	**3,68**
Kayaking	0,00	3,59	3,84	4,46	0,00	3,22	4,24	3,66	3,98	3,79	4,08	3,81	3,90	3,58	**3,30**
Climate	4,38	4,63	4,59	4,87	4,50	4,72	4,53	4,57	4,85	4,67	4,76	4,88	4,69	4,61	**4,66**
Generation average	**3,52**	**4,08**	**4,28**	**4,43**	**4,38**	**4,20**	**4,45**	**4,19**	**4,46**	**4,36**	**4,49**	**4,55**	**4,54**	**4,33**	**4,30**

Legend: M – Mean

Results per generation (Figure 1.) show high level of satisfaction of every examinee, their average grade, except the first assessed generation, being above average grade 4.00, and it is confirmed also by average grade of all examinees treated in the period from 2001 to 2015 (AS-4.30) Table 1.

Figure 1. Oscillations of average grades per generations

Discussion

Although average results for generations between year 2001 and 2015 are varying (Chart 1), it is noticeable that organizers are managing to keep the positive trend showing increasing satisfaction of Watersports students. Such a result is definitely not easy to maintain, concerning high results of satisfaction of examinees even in the first years (2003– 4,08). High level of teaching is shown also in the research by Oreb (2009) who has also, using questionnaire, determined high level of satisfaction among students in all the segments of realization of teaching, except transportation. But, transportation, or traveling, is one of the variables showing big increase in the satisfaction of students (from 2001 to 2015 the average grade increased from 2,51 to high 4,11 in the year 2014). It can be assumed that the construction of the traffic infrastructure and the opening of the highway A1 Zagreb – Ploče contributed to such an increase of satisfaction in the variable Traveling. Precisely by opening of mentioned highway section, duration of travel was decreased from 11 and half hours to 8 hours. High average grade for Climate (4,66) shows the importance of continuous investment in traffic infrastructure so that such a destination is brought closer to all the potential users.

High average of grades in the mentioned period for variables Teachers (4,51) and Assistants (4,59) shows constantly high level of quality of teaching in all four sports taught through Watersports classes. Also, it shows that attractiveness of individual sports as Sailing (4,40) or Windsurfing (4,38) compared to less attractive sports as Rowing (3,68) and Kayaking (3,30) hasn't influenced the student's assessment of quality of teachers and assistants. Finally, average result of grades for all the generations of 4.30 indicates high level of realization and satisfaction of students of Watersports class.

Conclusion

On the basis of the collected results, it is possible to conclude that:

- organizers of Water sports classes are able to maintain high level of teaching quality
- material means are totally satisfying the needs of students
- accommodation facilities, and especially food, are on a high level
- climate got the highest average grade, showing the characteristics of the area

Based on all the conclusions it can be said that population of students in the period between 2001 and 2015 is extremely satisfied with the Water sports collegium as a whole.

The assessment of any segment of teaching process made by student can only help future development and improvement. Regardless of high level of satisfaction, there should always be striving for even better.

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ANALYSIS OF THE LEVEL OF ANTHROPOMETRIC AND SPEED AGILITY CHARACTERISTICS OF MALE AND FEMALE PLAYERS AGED 11–12

Pačes Jiří , Juříková Jana, Zvonař Martin, Zháněl Jiří
Faculty of Sport Studies, Masaryk University Brno, Czechia

Abstract

A high level of fitness skills has been a sign of successful tennis players in recent years and its systematic training has become an integral part of the training process. Speed and its manifestations in modern tennis, where the trend is towards fast and powerful game, are the inherent attributes of successful tennis performance. The aim of this paper is to analyse the level of basic anthropometric and speed characteristics among young Czech tennis players, to assess inter-gender differences and to determine the correlation between individual variables. The research sample consists of Czech junior male tennis players (n=221) and female players (n=193) between the ages of 11.0 and 12.9 years. The data for this research was gathered specific agility speed test within a Czech tennis association project during the period of 2000-2015. Analysis of the acquired data shows normal distribution characteristics (verified by Chi-quadrate test). The anthropometric and speed variables were characterized by the basic statistical variables of the TEN-M set (male, n=221, body height: H=155.10±7.62 cm, body weight: W=43.50±6.68 kg, speed agility: SA=14.90±0.77 sec) and the TEN-F set (female, n=193, body height: H=154.60±6.94 cm, weight: W=43.49±17.17 kg, speed agility: SA=15.23±0.78 sec). Substantive significance assessment of differences between male and female tennis players using Cohen's d values showed a factually insignificant difference in basic anthropometric features (height, d=0.07, weight, d=0.00). A small level of substantive significance of the inter-gender difference, in favour of male tennis players, was found in the speed agility test (d=0.42, small). A sizeable substantive significance dependence between body height and weight was demonstrated for the TEN-M (male, r=0.71, large), the substantive significance of the dependence between speed agility, and height and weight, respectively, is small (r=0.15 or r=0.06, small), which means insignificant. In the case of the TEN-F there was again large substantive significance (female, r=0.75, large) between body height and weight, the relative significance of the relationship between speed agility and body height is medium (r=0.33, medium), between speed agility and weight is small (r=0.29, small) but, in both cases, it is higher than among the set of male tennis players. Among male tennis players and female tennis players between the ages of 11 and 12 years, the inherently insignificant inter-gender differences of anthropometric

characters and better results of the male tennis players in the speed agility test have been demonstrated. Substantive dependencies between body height and weight were established for both male and female tennis players, the dependence between the results of the speed agility test and the anthropometric features are insignificant in both sets (except for the dependence between speed agility and tennis height).

Key words: *anthropometry, inter-gender differences, speed, tennis, motoric test*

Introduction

Modern tennis can be characterized by high game intensity and poses high requirements for physical preparedness. Among the most important abilities, which have the highest impact on the sport performance in tennis, are speed, strength and coordination. Speed is mainly manifested in locomotion body motion, with running speed being the most important. Manifestation of running speed is the ability to start, accelerate, rebound and reactive strength and overall foot work (Ferrauti et al., 2014). Speed specific to tennis is primarily recognized as a speed in change of direction forward, backward and to the sides. To ensure correct timing during this direction change, constant acceleration and braking of individual body segments is required. The longest distance to cover in tennis is 14 meters to cross the court. At such short distances, it is not possible to reach the maximum speed, the player is in the first stage of acceleration, even before the so-called speed pickup (known as pick-up acceleration). For these reasons, the most used type of acceleration is using starting and explosive strength (Reid et al, 2003). According to Filipčič (2005), in junior tennis a game style prevails which is based on the game from the baseline without frequent net advances. Thus, in junior tennis, movement to the side prevails over moving forward or backwards. Acceleration being more important than direction change. From the perspective of ontogenetic development, significant growth changes begin during later school age (age 11-15), especially around 13 years of age when major differences between boys and girls start to manifest. This fact significantly impacts levels of strength and speed preconditions (Perič, 2012). Beginning at the age of 13, thickness of skinfolds noticeably increases in girls, and weight increases in boys. At this age, significant development of strength abilities occurs, especially in boys (Reid et al, 2003). Speed can be described as an ability to perform motor activity or realize specific movement task in the shortest time period (Hohmann, 2007). At the ages of 11 through 13, due to development of human organism, positive prerequisites to speed improvements are created. Increase in dynamics of speed-strength abilities is high and natural talent for speed of acyclic nature lowers at this age. (Hohmann et al., 2010; Zháněl 2005). Area of speed manifestation as a part of physical condition in tennis is very current topic studied by many authors in various publications (Ferrauti et al., 2014; Ulbricht et al., 2013; Schönborn, 2010; Reid et al, 2003; Crespo & Miley, 1998; Kovacs, 2006; Fernandez-Fernandez et al., 2014). Series of findings mention importance of physical condition abilities for overall tennis performance. Tennis-specific speeds, as a complex product of inter-muscle coordination, strength and speed, are considered to be one of the key conditional factors of sport performance in tennis (Ferrauti et al., 2014). Filipčič (2003) states that the test of speed (such as a 20-metre sprint) can be considered as a statistically proven predictor of later player's performance. This close correlation between the speed and the performance of a player explains that the high level of locomotive speed allows the timing of strokes, thus increasing their pitch and accuracy. Professional players attach great importance to physical condition and its training has become an integral part of training programs. Professionals specializing in this field are hired as a means to increase overall performance in player game manifestation. Tennis is seen as a game of extraordinary events where every game situation is different based on the balls played, which have different speed, height and spin every time. That is why so much demand is put on players speed especially in the first few steps of movement to every direction. This fact should be taken into consideration during the training process, which should authentically simulate game model, where the sprints up to 14 meters with direction changes are used (Kovacs, 2006).

During a tennis game, there are constant changes in the intensity of body movement between intensive load (2-10 seconds) and rest (10 – 20 seconds) during individual rallies. During side swap the rest time is between 60 and 90 seconds. Average game time is 1,5 hours, but in some cases game last for the excess of 5 hours. On average, during each stroke a player covers the distance of 3 meters, each rally is 8 to 15 meters in total with 3 to 4 direction changes. On average player covers distance between 1500 to 3600 meters during a match depending on the surface and game style (Fernandez-Fernandez et al., 2014), with 48% of movement being forward, 47% to the side and 5% backwards (Parson & Jones, 1998). Filipčič (2003) observed that e test of speed preconditions, specifically a 20-metre sprint is statically proven predictor of later player performance. Filipčič explains the close correlation between speed and player's success, by enabling faster stroke preparation and this attributes to an overall increase in the strength of the player's stroke. In tennis, speed is considered sport-specific, and it is about combining it with other attributes (Ferrauti et al., 2001). Very suitable means to assess speed preconditions in tennis is a short distance sprint test with side changes. This test is called „agility test" and it is often part of test batteries used for the assessment of specific physical condition abilities in tennis (Ulbricht et al., 2013).

Methods

The aim of this study was to analyse the level of basic anthropometric and speed characteristics of young male (n = 221) and female tennis players (n = 193) at the age of 11.0-12.9 years, to assess the inter-gender differences and to determine the degree of dependence between anthropometric and speed characteristics. From a methodological point of view, therefore, it was a deliberate choice. Research data were acquired during the years 2000 to 2015 using specific test of running speed with direction change which is part of the test TENDIAG1 battery.

The test is conducted as follows: a player stands inside of quadrilateral (40x40 cm) in the middle of the tennis court base line. After the start signal, the player always runs as fast as possible to the designated line, touches the medical missile on it and runs back to the quadrant on the back line. First, it runs to the right rear corner, then skewed forward to the right front corner of the spreading field, forward to the center of the spreading field, then sloping left to the left front corner of the submission field, and finally to the left rear corner. They perform three attempts, and the best time is recorded.

Based of the synthesis, the following three research question have been formulated:

1. What is the level of anthropometric characteristics and running speed of male and female tennis players in age range between 11-12 years old?

2. Do significant intersexual differences in levels of speed and anthropometric characteristics exist?

3. Can we prove a significant dependency rate between level of running speed and primary anthropometric characteristics?

Results

Analysis of research data of male and female players showed a normal distribution frequency of the observed variables (chi-squared test, variations on goodness-of-fit), however they were not acquired by random selection. Basic statistical characteristic of male (n=221) and female (n=193) players set are listed in table 1.

Table 1. Basic statistic characteristic of observed variables

Category	Male players (n=221)				Female players (n=193)			
Variables	M	SD	min	max	M	SD	min	max
Age	12.03	0.54	11.00	12.90	11.98	0.54	11.00	12.90
Height (cm)	155.10	7.62	140.00	178.00	154.60	6.94	135.00	172.00
Weight (kg)	43.50	6.68	30.00	72.60	43.49	7.17	28.20	66.80
SA	14.90	0.77	13.46	18.84	15.23	0.78	13.50	17.70

Legend: M … mean, SD … standard deviation, SA … speed agility

Assessment of substantive significance of median values using Cohen's d is noted in table 2.

Table 2. Assessment of substantive significance in intersexual difference

Category	Male (n=221)		Female (n=193)		Cohen's d evaluation
	M	DD	M	DD	
Height (cm)	155.10	7.62	154.60	6.94	0.07 (none)
Weight (kg)	43.50	6.68	43.49	7.17	0.00 (none)
SA	14.90	0.77	15.23	0.78	0.42 (small)

See Table 1 for legend.

Table 3. Assessment of substantive significance of values of correlation coefficient (Cohen's d)

Male	W	SA	Female	W	SA
H	0.71 (large)	0.15 (small)	H	0,75 (large)	0.33 (medium)
W		0.06 (small)	W		0.29 (small)

Legend: H ... body height, W ... body weight, SA ...speed agility

The results of basic statistic characteristics calculations of observed variables characterize research set of junior male and female tennis player in age 11-12.9 from the perspective of level of primary anthropometrics characteristics (male players height, H=155.10±7.62 cm, weight, W=43.50±6.68 kg; female players: height, H=154.60±6.94 cm, weight, W=43.49±7.17 kg) and speed parameters (male players: speed agility, SA=14.90±0.77 sec, female players: speed agility, SA=15.23±0.78 sec). From the results noted in table 1, we can observe that the difference of median values of primary anthropometric characteristics in set of male and female players aged 11–12.9 are relatively small. More significant difference (0.33 sec) was determined in speed agility.

Substantive significance assessment of median values of set male and female tennis players for each variable using Cohen's didn't show any distinction in intersexual differences in the case of body height (d=0.07) and weight (d=0.00) and small difference in speed levels among tennis players (d=0.42). Dependency rate between observed variables (height, weight, speed agility) was (due to the proved normalization of research data) determined using Pearson correlation coefficient, where values can be seen in table 3. Substantive significance was again assessed using Cohen (1988).

Substantive significance assessment of observed variables in set of male players demonstrated high dependence between body height and weight (r=0.71, large). Low dependency between speed agility and body height (r=0.15, small) and weight (r=0.06, small) respectively. In the set of female players expected substantive significance was demonstrated between body height and weight (r=0.75, large), medium dependency between speed agility and body height (r=0.33, medium) and low dependency between speed agility and body weight (r=0.29, small).

Discussion

The assessment of differences in the levels of basic anthropometric traits between the sets of tennis male players and female tennis players (height: dif=0.5 cm, weight: dif=0.01 kg) between 11.0-12.9 years is very small, of the population (Riegerová et al., 2006). Inter-gender differences between the level of basic anthropometric indicators (body height, weight) of male and female players aged 11-12.9 years are also minimal. Similar findings were presented by Fernandez-Fernandez et al., (2014) who found among German male tennis players (n=102) and female tennis players (n=65) insignificant inter-gender differences between players and female players at the height (male, M=149.6±7.8 cm, female, M=149.5±6.4 cm, dif=0.1 cm) and weight (male, M=38.5±5.8 kg; female, M=38.1±6.4 kg, dif=0.4 kg). The analysis of the results of the speed agility test of the male and female players we observed showed that the male players average slightly better than the female players (0.33 sec), but this difference is of little importance. Similar findings have also been made in Reid et al. (2003) who found that male players under the age of 12 achieved only slightly better results than female players (players M=2.00 sec, players F=2.02 sec, dif=0.02 sec). Slight differences were also found in 20-metre sprint (players M=3.57 sec, players F=3.58 sec, dif=0.01 sec). Also, Ulbricht et al. (2016) found the minimum inter-gender differences between German junior tennis players and national level tennis players (ages 11-12) in a 10-metre run (male, n=24, M=2.00±0.08 sec; female, n=17, M=±0.06 sec.). Similarly, the same set in a 20-metre sprint (male, M = 3.52±0.19 sec.; female, M=3.60±0.11 sec.) Also, Ferrauti et al. (2014) report that between 10 and 12 years, speed differences between girls and boys, as well as year-on-year changes are small. A study of Filipčič et al. (2004) shows minor differences in 20-metre sprint between players (n=52, M=3.71 sec) and toys (n=51, M=3.60 sec.) at the age of 13. Based on the results of the aforementioned studies, it can be stated that the inter-gender differences in the levels of tennis and teenagers' speed ratings in youth categories are very small and in fact insignificant. The highly significant dependencies were found among players and players of mean values between height and weight, correlated coefficients (male, r=0.71; female, M=0.75) correspond to the level found in the population (Riegerová et al. 2006), respectively. in German tennis players and tennis teenagers (Ulbricht et al., 2016), and in the case of dependence of body size and running speed, the average high speed and height dependence of teenagers (r=0.33) was found to be validated by Ferrauti et al. (2014) that the relationship between the basic body dimensions and the results of the speed test in this age category is insignificant.

Conclusions

Assessment of substantive significance of inter-gender differences between male and female players aged between 11 and 12 didn't show significant difference in case of primary anthropometric characteristics (body height and weight), however small difference between speed levels was demonstrated (in favour of male players). In the set of male players, substantive significance was demonstrated regarding the relation between body height and weight, low relation effect between height and running speed. Relation between weight and running speed was not proved. Among the set of female players (n=193) substantive significance between body height and weight and also between body height and running speed was demonstrated. Low relation effect was shown in case of female player between body weight and running speed. In conclusion, we can state that among male and female players between 11 and 12 years of age, there are no significant differences in anthropometric difference as well as in the case of speed in contrast with older age categories.

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INFLUENCE OF DIFFERENT AEROBIC PROGRAMS ON STABILITY PARAMETERS IN WOMEN

Péliová Katarína, Krnáčová Adriána, Kyselovičová Oľga
Department of Gymnastics, Faculty of Physical Education and Sport, Comenius University in Bratislava, Slovakia

Abstract

In the area of fitness exercise, the notion of adding number of group classes, followed by an increasing clients' base have been rapidly gaining traction in the current research. This paper has the objective to explore this phenomenon. It is generally accepted and scientifically approved that free time sport activities (e.g. fitness exercise) are beneficial for health and body. In addition to this, the postural stability, as an indivisible part of body movement, plays a significant role in daily life, considering its function of hindering body from falls. Thus, in our study, we observed and evaluated parameters of stability in adult healthy women, participated in 8-weeks aerobic programs: TABATA (TAB) and JUMPING (JUMP). Women´s basic somatometric data were observed: body height (BH), body weight (BW), body fat percentage (%BF) body mass index (BMI). The postural stability was registered by the FiTRO Sway Check System at the beginning and after the application of two different aerobic programs. 19 healthy adult, college students, who are not professionals in any sports were involved in the study. They were randomly divided in two groups: TAB (n = 8; age = 25.5 ± 4.75 years; BW = 63.14 ± 7.96 kg; BH = 167 ± 6.32 cm; BMI = 22.59 ± 2.44 kg/m² and %BF = 31.8 ± 4.71 %) and JUMP (n = 11; age = 25.00 ± 3.46 years; BW = 60.75 ± 9.46 kg; BH = 167.64 ± 7.97 cm; BMI = 21.55 ± 2.19 kg/m² and %BF 29.47 ± 5.18 %). Both groups were practising twice per week, with duration of 60 minutes per workout, and intensity of 60 – 90 % HRmax. *Methods:* the stability parameters were indicated by 30-second static balance test on stabilographic device. The test case comprises of two tests of stability: stand upright without visual control and tandem stance without visual control. Measured data: velocity of the CoM, velocity of the CoM in the direction antero-posterior and medio-lateral, mean distance from the middle of the CoM. To process and evaluate the data basic statistical characteristics were obtained. Additionally, the Wilcoxon T-test and Mann Whitney U-test were used for comparative analysis. According to a statistical significance we compare the results with a table of critical values ($p \leq 0.5$). *Results:* Stand upright without eyes control the velocity of the CoM in antero-posterior direction were 39.28 ± 26.39 mm in TAB and 51.22 ± 53.39 mm in JUMP. In medio-lateral the values were 41.28 ± 25.82 mm in TAB and 30.65 ± 35.84 mm in JUMP. Statistically significant changes were confirmed between input and output measurements in each group. Despite this we did not find statistically significant differences between the groups. *Conclusion:* We note that both of aerobic programs are beneficial for improving level of postural parameters.

Key words: *velocity of the CoM, CoM length, Tabata, Jumping, college students.*

Introduction

Free time sport activities are undoubtedly beneficial for health, body and mind. There are many evident advantages for doing aerobics, and different aerobic excercises are a common strategy for improving cardiorespiratory fitness and health. The recent studies indicated that aerobic programs reduce total and cardiac mortality by 20% to 26% (Taylor et. al., 2004). Many authors (Hoeger et al., 2018, Med, 2018) showed positive influence of such programs on $VO_{2max,}$ somatic parameters, strength, but rare or even missing studies of influence aerobic programs on postural sway. In our study we observed the influence of two different aerobic types of exercises on physiological, somatometric and postural stability parameters.

Postural stability is one of the basic ability in situations of daily life but also in almost all sports (Zemková, 2010). That's why it is important to investigate the possibilities of its improvements by many different exercises. The study of de Oliveira et al. (2014) evaluates the effect of three different exercises (mini-trampoline, aquatic gymnastics and general floor gymnastics) on postural balance in women. All modalities of exercise were efficient for improving postural balance after 12 weeks of training. People in this time do not involved sport for better state of their healthy but mainly for better external appearance.

Nowadays, many fitness goers are attending the group classes. **Jumping** or mini trampoline is getting more and more popular, especially within the females. Kanchanasamut & Pensri (2017) were shown mini-trampoline exercise may be used as an adjunct to other interventions to reduce risk of foot ulceration. In the study of Aragão, Karamanidis, Vaz, & Arampatzis (2011) there were shown that a 14-week mini-trampoline training intervention increased the ability of adults to recover balance during forward falls. Kidgell, Horvath, Jackson, & Seymour (2007) indicated that not only mini-trampoline workout is an effective tool for improving balance after lateral ankle sprain, but it is equally as effective as the dura disc. Atligan (2013) recommended use of trampoline training for postural control and explosive power improvement in children to sports trainer and physical education teacher.

Tabata or high intensity interval training is one of the most effective, most difficult and demanding high-intensity interval training methods at this time (Tabata et al., 1997). High intensity interval training has shown greater improvements in $VO_{2max,}$ endothelial function, cardiac contractility, blood pressure, insulin signalling (Schoenfeld, Dawes, 2009). With some little modification Tabata exercise can be safe and feasible for all age generation. Specifically, it might be even more beneficial in prevention of the general deterioration in lower limb flexibility and muscular strength, and also the cardiorespiratory fitness normally occurred with age (Chen & Liou, 2017). McShane (2013) mentioned 4 benefits of Tabata training: increasing the aerobic and anaerobic capacity, burning the fat, protecting the muscle tissue and it is short on time. In our study we focus on the influence of two different type of exercise on postural stability parameters.

Methods

Design of the study: In the study we observed and evaluated parameters of stability in adult healthy women, participated in 8-weeks aerobic programs: Tabata (TAB) and Jumping (JUMP). The reason for the inclusion of these activities is a dramatic increase in popularity among the fitness goers in recent years. Nineteen (19) healthy adult, college students, who are not professionals in any sports were involved in the study. They were randomly divided in two groups. Basic somatometric data were observed: age, body height (BH), body weight (BW), body mass index (BMI), body fat percentage (%BF), Tab 1. Both groups were attending the classes twice per week, with duration approximately of 60 minutes per workout, and intensity of 60 – 90 % HRmax, respecting "work and rest" intervals according to the program. To determine the HRmax and target heart rate we applied Karvonen formula (Åstrand et al. 2003; Benson, Connolly 2011; She et al. 2015).

Table 1. Basic somatometric characteristics of the experimental groups

	Sample (n)	Age [years]	BH [cm]	BW [kg]	BMI [kg/m²]	BF %
Tabata	8	25.5 ± 4.75	167 ± 6.32	63.14 ± 7.96	22.59 ± 2.44	31.8 ± 4.71
Jumping	11	25.00 ± 3.46	167.64 ± 7.97	60.75 ± 9.46	21.55 ± 2.19	29.47 ± 5.18

Structure of the lesson: Both programs had very similar structure of lesson. However, different methods have been used. After 15 minutes whole body warm up a specific main part has followed. **A continual aerobic intervention** (CT) with duration of 30 minutes and intensity of 60 – 90% HRmax has been applied in **JUMP program**. The basic locomotion movements were used such as jogging, scissors, step touch, jumping jack, heel jack, etc. **High intensity interval training** (HIIT) has been used in **TAB program**. In one rep we alternate a twenty seconds-work interval with intensity of 80 – 90% HRmax and ten seconds-rest. In total 8 reps were completed in one set. After 2 min rest we repeated this whole set 8 times. In this program we used mostly power and dynamic type of exercises such as squats, push ups, lunges, planks, abdominal crunches, jumping, jogging, etc. The session in both programs finished by 10-15 minutes static stretching and relaxing exercises for cooling down and HR decreasing to the rest level. Differences between two types of training are express in Tab.2.

Table 2. Characteristics of JUMP and TAB programs (HIIT – high intensity interval training, CT – continual training)

	Intensity	Type of training			Sets	Rest
Tabata	80-90% HRmax	HIIT	8 reps	20s work + 10s rest	8	2 min
Jumping	60-90% HRmax	CT	continual aerobic intervention		no	no

Testing: The postural stability was detected by the FiTRO Sway Check System (Hamar, 1993) at the beginning and after the application of two different aerobic programs (TAB and JUMP). The stability parameters were registered at 100 Hz by 30-second static balance test on force plate. The test case comprises of two tests of stability: stand upright without visual control and tandem stance without visual control. We assume that due to the age of our participants, it would be more appropriate to use the more demanding variant of both stability tests with the exclusion of visual control. All testing has been realised in the laboratory of Hamar institute of Human Performance at Faculty of Physical Education and Sports Comenius University. Parameters of balance: velocity of the CoM and its length in X-axes (antero-posterior) and Y-axes (medio-lateral), mean distance from the middle of the CoM.

Statistical analyses: To process and evaluate the data basic statistical characteristics were obtained. Additionally, for comparative analysis were used the Wilcoxon T-test for nonparametric comparison of two dependent files and Mann Whitney U-test for nonparametric comparison of two independent files. For all comparisons, a significance level of $p \leq 0.5$ was employed.

Results

There were shown statistically significant changes between input and output measurements of COM length in both of aerobic programs in medio-lateral and antero-posterior direction (Fig. 1, Tab. 3). In "Stand upright without eyes control" the average values of CoM length in **antero-posterior** direction were 160.74 ± 34.22 mm in TAB in comparison with JUMP 171.90 ± 49.36 (input measurements), 143.60 ± 31.01mm in TAB and 156.30 ± 62.55 in JUMP (output measurements.) In **medio-lateral** the values were 274.65 ± 69.20 mm in TAB and in JUMP 272.36 ± 87.65 (input measurements), 243.18 ± 54.78 mm in TAB and 240.13 ± 63.24 JUMP (output measurements).

The results of two independent files have shown none significant differences between two aerobic programs (Fig. 2). In "Stand upright without eyes control" the average increases of CoM length in antero-posterior direction were 39.28 ± 26.39 mm in TAB and 51.22 ± 53.39 mm in JUMP. In medio-lateral the values were 41.28 ± 25.82 mm in TAB and 30.65 ± 35.84 mm in JUMP.

Table 3. Average values of input and output measurements of COM length (X- and Y-axes) in TAB and JUMP

	Stand upright - eyes closed			
	Medio-lateral		**Antero-posterior**	
	day 0	day 56	day 0	day 56
	[mm]	[mm]	[mm]	[mm]
Tabata	160.74 ± 34.22	143.6 ± 31.01	274.64 ± 69.20	243.18 ± 54.78
Jumping	171.9 ± 49.36	156.3 ± 62.55	272.36 ± 87.65	240.13 ± 63.24

In "Tandem stance" the results were very similar to previous. There were significant changes between input and output measurements of COM length (X- and Y-axes) in TAB and JUMP, but not significant changes between different aerobic programs.

There were shown significant changes between input and output measurements in parameter of CoM velocity in both types of aerobic programs. The average values of input measurements were 12.51 ± 2.62 mm.s^{-1} in TAB and 12.71 ± 3.43 mm.s^{-1} in JUMP. The average values of output measurements as follows: 11.50 ± 2.41 mm.s^{-1} in TAB and 11.46 ± 2.95 mm.s^{-1} in JUMP (Fig. 3, Tab. 4).

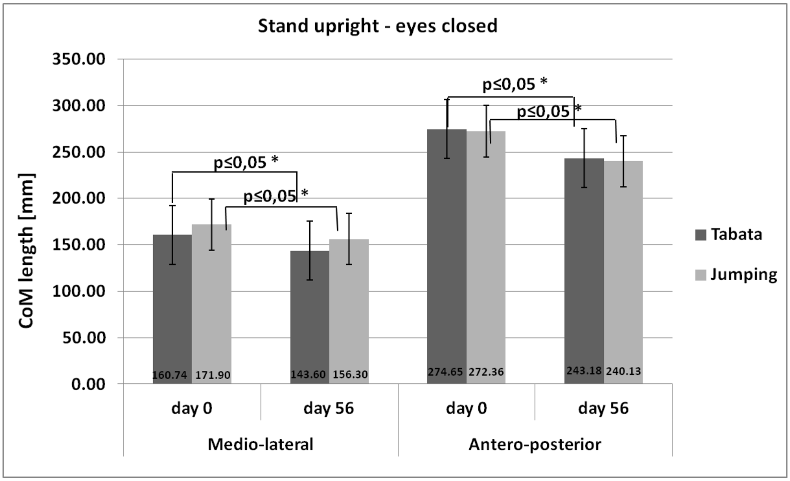

Figure 1. Average values of input and output measurements of COM length (X- and Y-axes) in TAB and JUMP

* = significant changes day 0 vs. day 56; p≤0.05; Wilcoxon T-test

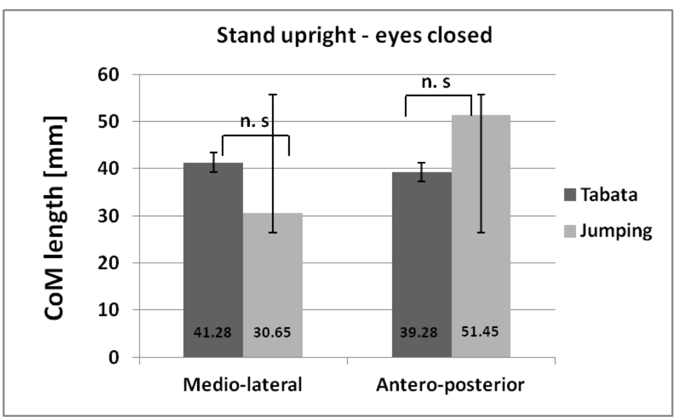

Figure 2. Comparison of average increases of COM length (X- and Y-axes) in TAB and JUMP

n. s = not significant changes day 0 vs. day 56; p≤0.05; Mann Whitney U-test

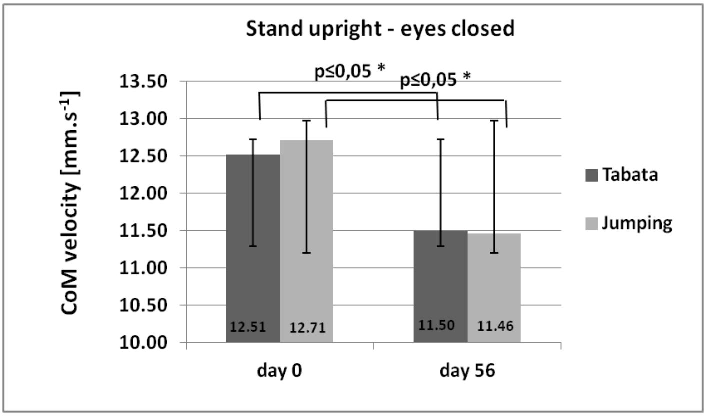

Figure 3. Average values of input and output measurements of COM velocity in TAB and JUMP

* = significant changes day 0 vs. day 56; p≤0.05; Wilcoxon T-test

Table 4. Average values of input and output measurements of COM velocity in TAB and JUMP

	Stand upright - eyes closed	
	CoM velocity	
	[mm.s^{-1}]	[mm.s^{-1}]
	day 0	day 56
Tabata	12.51 ± 2.62	11.5 ± 2.41
Jumping	12.71 ± 3.43	11.46 ± 2.95

There were shown no statistically significant differences between two independent files in parameter CoM velocity (Fig. 4). In "Stand upright without eyes control" the average increases of CoM velocity was 1.45 ± 1.28 mm.s^{-1} in TAB, and 2.48 ± 2.43 mm.s^{-1} in JUMP.

Statistically significant changes were shown in parameter of mean CoM length between input and output measurements in TAB and JUMP (Fig. 5, Tab. 5).

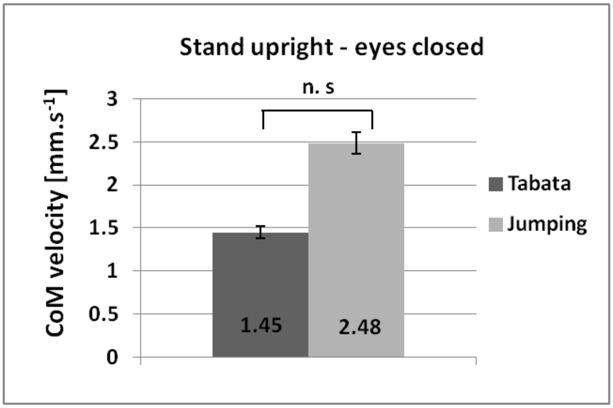

Figure 4. Comparison of average increases of COM velocity in TAB and JUMP

n. s = not significant changes day 0 vs. day 56; p≤0.05; Mann Whitney U-test

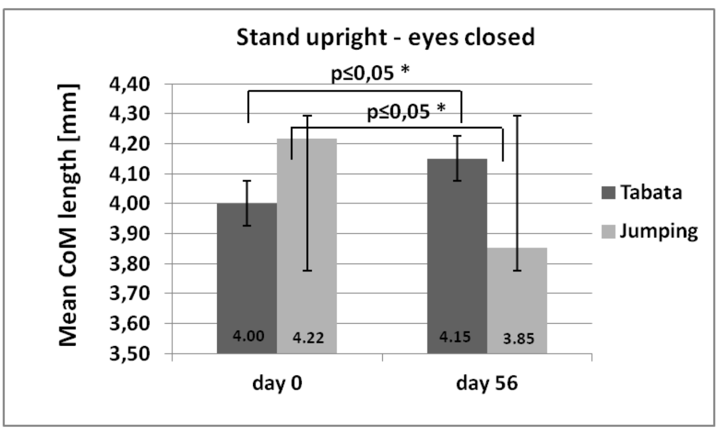

Figure 5. Average values of input and output measurements of mean COM length in TAB and JUMP

* = significant changes day 0 vs. day 56; p≤0.05; Wilcoxon T-test

Table 5. Average values of input and output measurements of mean COM length in TAB and JUMP

	Stand upright - eyes closed	
	mean Com length	
	[mm]	[mm]
	day 0	day 56
Tabata	4.00 ± 1.82	4.15 ± 1.86
Jumping	4.22 ± 1.22	3.85 ± 1.54

Differences between increases of mean CoM length in aerobic programs (TAB and JUMP) were not significant (Figure 6).

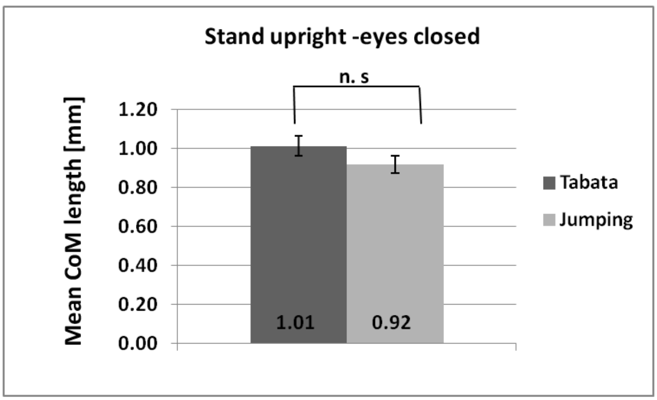

Figure 6. Comparison of average increases of mean COM length in TAB and JUMP

n. s = not significant changes day 0 vs. day 56; p≤0.05; Mann Whitney U-test

The results were very similar to previous ones in "Tandem stance". Significant changes of output COM velocity and mean CoM length in TAB and JUMP were shown in comparison with the input variables. Additionally, COM velocity and also CoM length increases showed no significant differences between TAB and JUMP groups.

Discussion

The main finding of this study is that both aerobic programs - Tabata and Jumping had positive influence on postural stability parameters in adult healthy women. There were significant increases between input and output testing. Postural stability is the basic ability in situations of daily life (Zemková, 2010). That's why it is necessary, even crucial to improve the level, or maintained the optimal one, when it is reached. Cafík (2015) declared that the combined training does not affect the development of postural stability. In contrary, our study showed, that Tabata and Jumping are both beneficial for improving parameters of postural stability in adult women.

Our findings are also in an agreement with Kidgell et al.(2007) that the mini-trampoline is an effective tool for improving balance. The results of de Oliveira et al. (2014) provide further evidence concerning exercise and balance and also contribute to the use of new forms of exercise for health promotion of women. All modalities of exercise investigated (mini-trampoline, aquatic gymnastics and general floor gymnastics) are efficient for improving postural balance of women after 12 weeks of training. Very similar results were shown in our study. Atligan (2013) recommended use of trampoline training due to the increased bipedal static balance, dynamic balance and vertical jump values in boys who do not exercise regularly. We identify with opinion that Jumping can be useful for improving postural ability in people who are not professional athletes. Other studies approved even more healthy benefits. The results in the study Kanchanasamut & Pensri (2017), for instance, showed that the weight-bearing exercise program using a mini-trampoline could decrease the feeling of numbness, and the number of people with DPN (diabetic peripheral neuropathy) with impaired pressure and vibration perception within a relatively short period of time. Mini-trampoline workout has very positive effect not only for cardiovascular system and respiratory system, but also benefit for psychical and mental state of person.

Tabata is one of the most effective, most difficult and demanding high-intensity interval training methods at this time (Tabata et al., 1997). McShane (2013) mentioned 4 benefits of Tabata training: increasing the aerobic and anaerobic capacity, burning the fat, protecting the muscle tissue and it is short on time. It was the main reason for including such program to our study. Despite the fact that one could doubt its influence on balance parameters, our findings showed that Tabata can improve also postural stability. With the respect of high intensity interval training we included various exercises in TAB program for improving the core system (push ups, planks, abdominal crunches) which could positively influence also balance and postural sway. Benefits of high intensity exercise on postural sway and balance are also supported by Zemková (2010) who noticed that cycling at higher revolution rates has greater initial postural sway than after cycling at lower revolution rates. It approved the idea that it is possible to improve postural parameters by intensive training. Additionally, high intensity interval training can be a time-efficient to improve cardiorespiratory fitness and reduce body fat levels over and above what is possible through steady-state aerobic training (Schoenfeld, Dawes, 2009).

Limitation of the study

Relatively short duration of training programs (8 weeks) and the small sample size are the main limitations of our study. Additionally, a control group was not involved.

Conclusion

Based on our results we can note that both aerobic programs are beneficial for improving level of postural parameters in healthy adult women – college students. Although significant differences between Jumping and Tabata workouts were not shown, groups improved their postural ability after 8-weeks training intervention in both cases. This finding is very important, particularly from the practical point of view as postural stability is one of the basic ability in daily life situations. The level of postural ability can be positively influenced by interesting aerobic programs. That's why it is important to investigate the possibilities of its improvements by many different exercises.

Acknowledgements

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INFLUENCE OF PHYSICAL ACTIVITY ON EXECUTIVE FUNCTIONS IN CHILDREN WITH INTELLECTUAL DISABILITIES

Protic Mladen[1]*, Válková Hana*[2]
[1]*Department of Adapted Physical Activity at Faculty of Physical Culture, Palacky University Olomouc*
[2]*Division of History, Phylosophy, Sociology and Psychology of Sport at Faculty of Sport Studies, Masaryk University*

Abstract

*Purpose***:** Children with intellectual disabilities (ID) usually show impairments in executive functions (EF). Most of the studies with children of typical development have shown positive influence of physical activity (PA) and exercise on executive functioning. Therefore, objective of the study was to determine relationship between PA and EF in children with mild and moderate ID. We wanted to find out are those that are more physically active also better in scores of EF, respectively does PA predict scores of EF. *Methods***:** One hundred and four children (62 boys and 42 girls) with ID from 7 to 18 years of age from 7 Special schools and 2 special classes in 6 cities of Bosnia and Herzegovina (B&H) took part in the study. There were 49 children with mild ID and 44 with moderate ID. For assessment of EF, we used BRIEF - Behavior Rating Inventory of Executive Functions - teacher version that was completed by 15 special education teachers of children participating in the study. Physical Activity in terms of sedentary, light, moderate, vigorous PA and moderate to vigorous physical activity (MVPA) was assessed with GT3X Actigraph accelerometer during 7 consecutive days. *Results***:** There was significant relationship between PA and EF in 4 out of 8 BRIEF scales for certain type of PA. The most statistically significant correlations were between Initiate, Working Memory and Plan/Organize scale of EF and Moderate PA, Vigorous PA and MVPA. In addition, regression analyses have shown that moderate PA was most significant predictor of initiate, working memory and plan/organize scales. *Conclusion*: PA and EF are related to each other in children with ID but not for all BRIEF scales and not for each PA level. Our study confirmed some of results from previous studies that PA positively influences EF. So, future research may focus on determining appropriate PA and exercise intervention that would influence development of EF in children with ID.

Key words: *Executive functions, physical activity, exercise, intellectual disability, actigraph, accelerometer, BRIEF*

Introduction

Executive functions are crucial for children's lifetime performance (CDCHU, 2011). They are often related to school readiness and school achievement (Morrison et al., 2010), physical health (Miller et al., 2011), successful work (Bailey, 2007) and quality of life (Brown and Landgraf, 2010). According to the various tests measuring different type of EFs they start to develop shortly after birth and most significant development is occurring between ages 3 to 5. Development continues during adolescence and early adulthood and then it starts to decline in later life after 50's (Weintraub et al., 2013).

There are a lot of different definitions and classifications of EF, but the model that was chosen for this study is developed by Gioia et al., (2000), who defined EF as collection of processes that are responsible for guiding, directing and managing cognitive, emotional, and behavioral functions, especially during new, problem solving situations.

A numerous research over the past two decades has provided supportive evidence that PA is related to EF (Verburgh et al., 2013). The earliest evidence about this relationship is coming from the middle of past century when Piaget & Inhelder (1966) discussed that cognitive development relies on motor functioning. Relatively recent studies supported existence of relationship between development of motor skills and EF with findings based on temporal and spatial similarity in development of these two domains (Diamond, 2000; Wassenberg et al., 2005). It was discovered that they develop at the same time and that they are using same brain structures.

Data from cross-sectional studies suggest positive influences of fitness training on human brain structure and cognitive function (Kramer and Erickson, 2007). Kramer et al., (2001) showed that over a 6-month period, a group that engaged in moderate walking not only became more aerobically fit, but also showed enhanced executive processing, as indexed by better performance in inhibition and attention.

In order to find the best pattern for EF improvement there were a lot of studies examining influence of acute single bout exercise (Hillman et al., 2009) and several weeks' long chronic exercise (Davis et al., 2011) on EF. These experimental studies suggest that single bouts of aerobic exercise may only temporary improve children's EF, while chronic participation in aerobic exercise may produce more sustainable improvements to EF.

Several studies have shown that amount of EF engagement during the exercise appears to be an important factor, such as for example activity that includes character development (e.g., traditional martial arts) or both exercise and mindfulness (e.g., yoga). Therefore, Lakes & Hoyt, (2004) found that students who practiced *tae kwon do* instead of physical education (PE) class, improved more in working memory and on all dimensions of inhibitory control, than students who had only standard PE. Moreover, the study of Gothe et al., (2013) showed that cognitive performance after the yoga exercise bout was significantly better compared to aerobic exercise.

Trends in the research of ID have changed in the last two decades, and cognitive processes and their relationship with different type of behaviors such as PA are starting to be topic of interest among researchers (Oliver, 2014). Therefore, the intention of this study is to examine the relationship between EF and PA in children with ID. As an additional goal we wanted to provide the status of EF and PA participation in children with ID from B&H.

Methods

Participants

104 children took part in this study, 62 boys and 42 girls with ID from 7 Special schools and 2 special classes in 6 cities of B&H. There were 49 children with mild ID (IQ scores 50–70) and 55 children with moderate ID (IQ scores 35–50) without comorbid disorders and cause of ID was of unknown aetiology. Information about children's IQ (WHO 1992) and ID was taken from the school's records. The age range of the children was from 7 to 18 (M=14; SD =3.3).

Instruments

Executive functions

BRIEF (Gioia et al., 2000) is a questionnaire for assessment of EF behaviors in home and school environments designed to be used with children ages from 5 to 18. Unlike performance based tests of EF that have certain limitations (Pennington and Ozonoff, 1996), BRIEF is psychometrically sound instrument with good ecological validity that allows assessment of EF from perspective of daily basic behavior, and presents them in a more realistic everyday condition. In our study we used BRIEF – teacher version that contain 86 items within eight theoretically and empirically derived clinical scales that measure different aspects of EF: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitor. Factor analysis of both versions of BRIEF supported two-factor model. First factor was identified as Behavioral Regulation Index (BRI) which consists of scales Inhibit, Shift and Emotional Control and second factor called Metacognition Index (MI) includes five remaining scales. The two factors demonstrate moderate correlation between each other and they are used for calculation of the Global Composite Index (GEC) score. BRIEF has two validity scales, Inconsistency – extent to which respondent answers similar BRIEF items in an inconsistent manner; and Negativity – extent to which respondent answers selected BRIEF items in an unusually negative manner.

BRIEF teacher version was normed on 720 children and Cronbach alpha as measure of internal consistency ranged from 0.84 to 0.98. The BRIEF was translated into the Bosnian language for one of the earlier studies performed by Memisevic & Sinanovic, (2013) using bilingual translation method. Instrument was not standardized and validated for Bosnian cultural environment but it is shown to be feasible (Roth et al., 2015) and with same factor structure (Memisević, 2015) in use with children with ID as original version. Fifteen special education teachers of children with ID filled in the BRIEF. The condition for teachers to fill in the BRIEF is to know the child minimally 6 months.

Physical activity

Physical activity levels in relation to sedentary, light, moderate, vigorous and MVPA was obtained using the GT3X Actigraph accelerometer (ActiGraph TM, Fort Walton Beach, FL, USA; Firmware 4.4.0) for 7 consecutive days.

Participants, parents/caregivers and teachers in schools were provided with instructions for wearing the actigraphs including placement and wear time. Instructions were given to the participants and parents/caregivers both verbally and in written on how to wear the actigraphs during all waking hours except while bathing, showering, swimming, sleeping and playing contact sports. The actigraph was fitted to a small bag and attached to the participant's right hip. Each bag had a number which was assigned to the actigraph and child wearing it. Actigraphs were programmed to measure activity in 30 second epochs. In order to be included in the analysis participants had to wear actgraph minimally 4 days (Berlin et al., 2006) 8 hours a day (Einarsson et al., 2015).

The minimum number of counts for MVPA was defined at ≥ 2296 counts.min-1, sedentary activity as ≤ 100 counts.min-1 and vigorous was set on 4012 counts and above. These thresholds were first established by Evenson et al., (2008) and later independently validated by Trost et al., (2011). Application of actigraphs is shown to be feasible with children with ID (Valkova et al., 2014; Einarsson et al., 2015).

Data analysis

Statistical analysis was conducted using statistical software STATISTICA v. 13 (StatSoft, Prague, Czech Republic). Physical activity data from actigraphs were analyzed with ActiLife Software version 5. We haven't found any statistically significant difference between children who wore actigraph 4, 5, 6, or 7 days in mean scores of moderate PA ($F= 1.6$, $p= 0.16$), vigorous PA ($F=1.23$, $p=0.23$) and MVPA

(F= 0.95, p= 0.45). Results obtained by BRIEF are so called raw scores. They had to be converted to *T* scores (M = 50, SD = 10) according to the normative data (adjusted for gender and age) provided in the Professional manual (Gioia et al., 2000) and they are used to interpret the child's level of EF. T scores that were above the limit of 65 (1.5 SD above the mean from the norm sample) were considered clinically significant (abnormally elevated). Lower scores indicate better functioning. Physical activity results were presented in number of minutes spent in certain PA level (sedentary, light, moderate, vigorous and MVPA).

First, descriptives were calculated for EF and PA scores by gender and level of ID. Second, relationship between BRIEF scales and PA levels were calculated with Pearson correlation coefficient. The relationship was interpreted by Cohen (1992): r = 0 – complete independence; .00< r < .20 – very weak dependence; .20 ≤ r < .40 – low dependency; .40 ≤ r < .70 – medium dependence; .70 ≤ r < .90 – high dependence; .90 ≤ r < 1.00 – very high dependency; r = 1 – total dependency. In order to determine contribution of PA to EF, General Regression Models (GRM) – multiple regression analysis (stepwise backward method) was conducted. An alpha level of p < .05 was set for all statistical tests.

Table 1. Results of EF BRIEF scores and PA levels

	All (*N*= 104)		Boys (*n*= 62)		Girls (*n*= 42)		Mild ID (*n*= 49)		Mod ID (*n*= 55)	
EF [*T* scores]	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
In	66.3	17.1	67.4	17.3	64.6	18.3	58.9	11.6	72.9	19.6
Sh	78.1	20.9	78.7	22.5	77.1	18.4	67.2	15.2	87.7	20.6
EmC	69.6	18.8	71.1	20.3	67.4	16.4	63.1	15.1	75.3	20.0
BRI	72.6	17.8	73.6	19.5	71.1	15.2	63.9	12.7	80.3	18.3
Int	71.2	14.8	73	16.0	68.6	12.8	64.3	13.5	77.4	13.3
WM	74.2	18.7	77.3	19.6	69.7	16.6	65.5	14.9	82.1	18.4
PO	67.5	13.1	69.3	13.8	65.0	11.6	61.7	11.0	72.7	12.7
OM	67.3	23.4	71	24.3	61.7	20.9	57.5	16.1	75.9	25.4
Mon	70.5	16.4	70.9	16.1	69.8	16.9	63.0	13.1	77.1	16.2
MI	74	17.5	76.5	17.9	70.1	16.2	64.5	13.1	82.4	16.6
GEC	75.1	18.5	77.5	20.4	71.5	14.8	65.3	13.6	83.8	18.0
PA [min/day]										
SPA	487.2	159.1	462.3	171.5	523.8	132.4	469.5	155.8	502.84	161.9
LPA	260.9	91.3	269.0	90.6	248.9	92.2	295.5	90.8	230.09	80.8
MPA	26.6	19.6	30.7	21.1	20.9	15.9	34.3	20.4	20.14	16.6
VPA	8.8	10.5	9.8	11.2	7.3	9.4	11.4	11.5	6.5	9.1
MVPA	36.3	29.1	42.2	32.3	27.5	21.2	47.6	31.0	26.66	23.7

Note. n= sample size, EF= executive functions, M= mean, SD= standard deviation, Mild ID= mild intellectual disability, Mod ID= moderate intellectual disability, In= inhibition, Sh= Shift, EmC= emotional control, BRI= behavioral regulation index, Int= initiate, WM= working memory, PO= plan/organize, OM= organization of materials, Mon= monitor, MI= metacognition index, GEC= global composite score, SPA= Sedentary Physical Activity, LPA= Light Physical Activity, MPA= Moderate Physical Activity, VPA= Vigorous Physical Activity, MVPA= Moderate to Vigorous Physical Activity.

Results

Descriptive results of EF BRIEF scales and PA levels are presented in Table 1. As can be seen from the table children with ID scored above 1.5 SD (clinically significant score) on all BRIEF scales. We performed *t*-test, that was not presented in tables, first between mean scores of boys and girls on BRIEF scales and only difference was found on working memory ($p= .04$) and organization of materials ($p= .04$) scales. It is interesting to mention that boys had all scores above 1.5 SD, while girls had above 1.5 SD on all except on inhibition and organization of materials scales. Moreover, second *t*-test was between the mean scores of children with mild and moderate ID and children with mild ID performed better. The difference in the mean scores was statistically significant for all clinical scales ($p < .001$). It is important to mention that children with mild ID had clinically significant result only on shift, working memory and GEC scales, whereas children with moderate ID scored above 1.5 SD on all BRIEF scales. Boys and girls did not differ much in PA results and significant difference was present only for moderate PA ($p= .01$) and MVPA ($p=.01$). Differences in PA results in relation to ID were more visible and children with mild ID performed better for all PA levels ($p< .05$) in comparison to children with moderate ID.

After testing the relationship (Pearson correlation coefficient) between PA and EF BRIEF scales in the whole sample of participants we have found several negative correlations presented in Table 2. Correlations found were with low dependency ($.20 \leq r < .40$) with 3 BRIEF scales (initiate, working memory and plan/organize) and 2 PA levels (moderate PA, and MVPA intensity) being in focus. It is worth mentioning that same significant correlations ($.20 \leq r < .40$) were found in sample of children with mild ID (regardless to gender) and in sample of boys only with medium dependence ($.40 \leq r < .70$).

Table 2. Pearson correlation between the results of PA and EF in whole sample of participants

BRIEF	SPA	LPA	MPA	VPA	MVPA
In	-0.14	0.04	-0.06	-0.05	-0.07
Sh	-0.11	**-0.23**	**-0.23**	-0.13	**-0.22**
EC	-0.12	-0.04	0.02	0.03	0.03
BRI	-0.15	-0.06	-0.09	-0.06	-0.09
Int	0.07	-0.17	**-0.33**	**-0.20**	**-0.32**
WM	-0.06	-0.16	**-0.27**	**-0.21**	**-0.28**
PO	-0.10	**-0.20**	**-0.27**	-0.13	**-0.25**
OM	-0.17	-0.09	-0.09	-0.08	-0.10
Mon	-0.11	-0.03	-0.15	-0.14	-0.16
MI	-0.05	-0.17	**-0.27**	**-0.21**	**-0.28**
GEC	-0.12	-0.13	**-0.20**	-0.13	-0.20

Note. BRIEF= Behavior Rating Inventory of Executive Functions, SPA= Sedentary Physical Activity, LPA= Light Physical Activity, MPA= Moderate Physical Activity, VPA= Vigorous Physical Activity, MVPA, Moderate to Vigorous Physical Activity, Bolded results represent statistical significance; $p < .05$.

Finally, in Table 3 we presented results of GRM – Multiple regressions (stepwise backward model) to see contribution of individual levels of PA on each BRIEF scale individually. As can be seen from table moderate PA was significant predictor for Initiate, Working Memory and Plan/Organize scales. Coefficients were low and moderate PA explained 6 % of variance in working memory and plan/organize scales and 10 % in initiate scale.

Table 3. GRM – multiple regression analysis - Contribution of moderate PA on Initiate, Working memory and Plan/Organize BRIEF scales scores – 3 models

Predictor / Dependent	B	StE B	t	p	R^2	Adjusted R^2
Moderate PA / Initiate	-.33	.10	- 3.49	< .0001	.11	.10
Moderate PA / Working memory	-.27	.10	-2.82	.006	.07	.06
Moderate PA / Plan/Organize	-.27	.10	-2.74	.007	.07	.06

Note. PA= physical activity, $p < .05$

Discussion

The goal of this study was to examine relationship between EF and PA in children with ID through use of BRIEF – Bosnian translation and Actigraph GT3X, and to see what is the status of EF and PA in children with ID.

We found that there is relationship between EF and PA, but not between all EF components and all PA levels. The strength of found relationships between variables of these two domains indicated low to medium dependence, with negative correlations meaning that with increase of certain level of PA there is a decrease of specific EF BRIEF scores, or better results.

Some of our findings are in line with earlier studies on similar topic. For example we found that planning component of EF is related to greater participation in moderate PA, vigorous PA and MVPA. In one earlier study Hartman et al., (2010) have been examining relationship between gross motor skills and EF using Tower of London (TOL) test for EF that beside problem solving and decision making is measuring planning ability as well. They discovered positive correlation between planning ability and gross motor skills in children with mild ID.

Even though motor skills are not subject of our research they are very important factor that positively influence PA participation in children with ID (Lloyd et al., 2014). Most recent study of Hartman et al., (2017) revealed that skill related fitness was significantly related with inhibition and cognitive flexibility (shift). Our study contradicts to finding related to inhibition as we haven't found any relationship there, but supports finding related to shift.

Beside planning, we found that working memory, initiate and shift scales were related with moderate PA, vigorous PA and MVPA. Shift component also found to be related with PA in study performed by Ringenbach et al., (2016) who reported improvement in shift component after 8 weeks of voluntary cycling (30 minutes, 2 times per week) in children with ID. With regards to working memory, Geertina Houthuijzen, (2013) has found that low BMI and higher reported PA can improve this EF component especially visuo-spatial short term memory.

We could not find similar study including initiate scale and PA with this population, except one study conducted with University students (without ID) where initiate scale was found to be significant predictor of PA (Sweet, 2016), so more research is definitely needed in this area.

As for emotional control, organization of materials and monitor, we haven't found studies involving these 3 components in relation to PA with this population to be able to discuss in more details.

Regarding EF results separately, we could say that children with ID have clinically significant or near-clinically significant delay in EF behaviors on all BRIEF scales. The finding is in line with other studies in this area (Hartman et al., 2010; Memisevic and Sinanovic, 2013). Three areas of EF found to be most impaired in our study are shift, initiate and working memory and similar was found in study of Memisevic & Sinanovic (2013) who also used BRIEF for EF assessment. These results further demonstrate validity of the BRIEF, as working memory is known to be impaired in children with ID and that the deficits in working memory increase with the degree of ID (Schuchardt et al., 2010). Unlike Memisevic & Sinanovic, (2013) who haven't found any significant difference in scores between girls and boys, we found it in scores of working memory and organization of materials. As we haven't found any other study related to sex differences more research is needed here. Significant difference was found on all BRIEF scales in relation to level of ID in favor of children with mild ID who had better scores, which is also in line with previous findings in this area (Memisevic and Sinanovic, 2013).

Physical activity results showed that 20 % of participants met the recommended guidelines of 60 minutes of MVPA daily (World Health organization, 2010). Boys were more active than girls and 81 % of them met the guidelines comparing to 14 % of girls. Also, children with mild ID were more active that children with moderate ID and 71.4 % of those who met guidelines were children with mild ID. The findings in our study related to PA and children with ID are similar to those in earlier studies (Lloyd, 2016), saying that more research is needed to develop most effective programs for this population and to promote PA in this population.

There are few limitations in our study. Norms for different PA levels are based on results of children with typical development, so we cannot be sure it reflects reality. Also, there are some limitations for BRIEF related to objectivity and inter-rater reliability because different teachers might perceive certain behaviors differently. In order to avoid this, we provided teachers with clear instructions and we also monitored data collection by checking potential concerns about completion of the BRIEF via e mail and phone.

Conclusion

Based on our results we can conclude that EF (Shift, Working memory, Initiate and Plan/Organize) and PA (moderate, vigorous, MVPA) are related to each other in children with ID but what are the underlying mechanisms of this relationship we still don't know. In order to determine how these two domains affect each other, future research may focus on discovering what type of PA is beneficial for what type of EF, what kind of PA/exercise intervention, frequency and its duration is sufficient, and for what age and type of ID. Last but not least, what assessment methods and research approaches would be the best to determine relationship between PA and EF.

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THE INFLUENCE OF SOCIAL INTERACTION: MOTIVATION GAIN OF GROUP TRAINING IN CHILDREN

Strašilová Kateřina, Vajda Petr
Masaryk University, Faculty of Sport Studies, Brno, Czech Republic

Abstract

It could be assumed that exercise motivation is influenced by many psychological factors including enjoyment, social influence, and self-efficacy. Effect of group exercise is sometimes a neglected factor although it has been shown it leads to higher performance, especially with more capable partners. The aim of this study was to report on the effect of social-comparative feedback to physical performance of children aged from nine to eleven years. The study involved 14 young elite synchronized female swimmers from the Czech Olympic Club who compete at an international level (age M=10.02±0.66). This research was conducted in an experimental design. Two girls had to terminate their participation in the research. The influence of social interaction was examined in two different physical performances, i.e. isometric strength and dynamic strength; in two separately measured rounds, i.e. as individuals and as a group. There was a week interval between the rounds. In the first test girls were required to hold a wall seat position as long as possible and in the second test maximum vertical jump was measured. A sample of participants was randomly split into two groups; one started with an individual and the other with a group exercise for both testing methods. During the individual try only the researcher was present in the place. In the group test there were all members of the test group together in the same time and place. The mean performance in the individual try for vertical jump was M=15.63±4.59and M=17.19±4.61 for the group one. In the wall seat test it was M=107.07±72.18 (individual) and M=216.21±140.47 (group). The influence of social interaction in the group was evaluated by *Cohen's d* which showed high substantive differences (dynamic strength d=0.33, small effect; isometric strength endurance d=0.99, large effect). The *Wilcoxon matched pair* test was used for data analysis (results were significant, P< 0.05). The results showed exercising in groups caused improvement in performing vertical jump and wall seat exercise. To sum up, we found out children´s physical performance could be affected by social interaction, i.e. mutual encouragement within a group. However, the effect fluctuated in the sample. Therefore, it could be concluded that group exercise is beneficial for children training as well as other factors such as positive verbal motivation, constructive feedback, and appraisal. Ethics: Prior to the beginning of this research, all under-aged synchronised swimmers´ parents were

thoroughly informed, agreed on their children´s participation in this research, and signed consensus forms.

Key words: *group cohesion, mutual encouragement, self-motivation, sport performance, synchronized swimming, youth athletes*

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Introduction

Children physical performance is highly variable and is influenced by their motivation to exercise, especially when exercise is dull, demanding, or hurting. We can explain the cause and purpose of our efforts to adults and it may influence their motivation. However, with children, it is not always so simple. Children often do not understand reasons why they should do something they do not particularly enjoy (Puddefoot, Hilliard, & Burl, 1997).Performance does not play a same role in children as in adults. Be with their friends during the sport is much more important for them (Linz, 2016).Strength training can be one of such types of exercise although it should be a necessary part of training for every young athletes, because it brings many benefits, e.i. injury prevention, strength gains and improving physical performance, increased bone mineral density or improved mental well-being (Kraemer & Fleck, 2005; Zatsiorsky & Kraemer, 2006). Many authors are concerned with issues of strength performance, whether in adults or children, the different nature of static and dynamic strength performance, and the testing of muscle strength of athletes (Haff, Triplett, & National Strength & Conditioning Association (U.S.), 2016; Zháněl et al., 2015). It was found, there are many psychological factors which influence sport performance. Enjoyment (Hardy & Rejeski, 1989), self-efficacy (McAuley & Courneya, 1993), and social influence (Carron, Hausenblas, & Mack, 1996) appear to be the most prominent. Nevertheless, the influence of exercising in a group is sometimes neglected. It has been shown social interaction in a group leads to higher exercise adherence than in individual programs. There were differences according to manner of delivery of intervention; the effect was higher in the studies which used direct face to face interaction of athletes, than compared with physically absent partners (Weber & Hertel, 2007). Köhler (in 1926) was the first one, who systematically described benefits and effectiveness of this effect of exercising in group. He found out members of a group (especially weaker ones) performed better than when they performed as individuals; and their improvement was most obvious when the differences between weaker and stronger members of the group was not too large (Kerr & Hertel, 2011). Feltz, Kerr and Irwin (2011) tested the effect of group exercise on performance in five isometric exercises. They stated that exercising with a more capable partner causes a 24% performance increase (d0.99). Kerr et al. (2007) stated that presence of superior members may lead to an increase of personal performance and reaching higher goals in lower members of a group. Group work, thus, creates an opportunity for social comparison that generates motivation gains. Stroebe et al. (1996 in Weber & Hertel, 2007) described that information about other group members´ performance is one of the main moderator in group motivation gain. When this information is available during exercising, it can cause comparison and competition processes. It seems that motivation to perform better results comes from tendency to cope with the group through the process of social comparison (Weber & Hertel, 2007). Another factor affecting performance is physical presence of group members. Recent studies have demonstrated the influence of on-site present partners. Some studies state that the mere presence of other group members leads to higher individual performance (Carron, Burke, & Prapavessis, 2004). Allen and Hecht (2004) state group work is considered by many professionals to be a major factor that could motivate individuals to work much harder. The aim of our study was to find out whether there is any effect of exercising in the group on the physical performance of children at all, and if so, if this effect affects equally isometric and dynamic strength performance. Synchronized swimming is very complex sport with varied training. Both types of described strength are often used in performance. A great training load and internal competition for the A-team membership is typical for this sport. So especially the dryland's training quality could by increased by using a proper group exercise and the social interaction inside the training group.

Methods

Subject

A number of sixteen girls at the age ranging from eight to ten were randomly split into two groups of eight. The girls were young elite synchronized swimmers from the Czech Olympic club who compete at an international level. The physical performance was set up in two separately measured rounds, i.e. as individuals and as a group. The first group started with the individual exercise and the other one with the group. By this approach we controlled effect of previous experience with testing session. There was one week interval between the rounds. Two girls had to terminate their participation in the research, for their health reasons. So out of the original number of sixteen, only fourteen participants took part and completed the research; examined groups changed in number (7:7).

Consent

Prior to the beginning of this research, all under-aged synchronised swimmers´ parents were thoroughly informed on this research and they were provided with the following explanation of reasons for which the research would be carried out: 'a research to find out how well children can perform a specific exercise at two different occasions'. They agreed on their children´s participation and signed appropriate consensus documents.

Procedure

There were two tests held, which were to examine different physical performance. First one was a wall seat position test (isometric strength) and the other one was a vertical jump test (dynamic strength). All of the girls participated in both tests, in the individual as well as the group one, so we got data to compare performance with or without present of teammates for every participant. In this way, we were able to measure the effect of the exercise in the small social group (half of the team) on physical performance in selected examinations. In the former test, the subjects leant against a wall which supported their backs with arms held forward; and the ankles, knees, and hips bent at the right angles, as if they were sitting on an imaginary seat (fig. 1 and 2). In the latter test, there was maximum vertical jump (fig. 3, 4 and 5) tested. Wall seat position was performed in two separate rounds. It was tested at the same time of a day with one-week interval. There were only subjects and a tester present in the room and girls were not allowed speak during the measurements. Performance duration was recorded for each occasion and later used to interpret the findings. The subjects were instructed flowingly: "Girls, I would like you to hold the wall seat position as long as you can. When it starts to hurt too much or you get too tired only then you can sit on the floor and leave the room. Do you understand what to do?" Girls did not learn their results after their first round. When the subjects visibly violated the position, for example their arms went lower, they were immediately asked to adjust it. If they did not adjust the position immediately, the exercise was ended. Testing of maximum vertical jump took place similarly (two separate rounds on the same day and time of week, one half started with individual test, one with group test). Only tested subjects and a researcher were present in the room and girls were not allowed to speak during the testing. Prior to the test itself, each subject stood up next the wall so they had it on their right/left side and reached up with their hand as high as they could. The tester marked their originally reached height from the standing position. Then the participant moved 10 cm away from the wall and jumped up vertically as high as possible with using both arms and legs. The participants had a marker in her hand so she could mark the highest point she was able to reach. The difference in distance between the original mark from standing position with one arm raised up and the one marked at the vertical jump height was the score. All of the attempts were recorded, the best one was used for our research. Prior to the test, the subjects were given the following instruction: "Girls, first I would like you to stand up next to the wall from the side which you hold your marker in, raise your hand up with a marker, point your marker against the wall and put a mark at the highest point you reach. After that you step away 10 cm from the wall, I will measure and record the height of your mark. After that you will stand up there again and you will jump up five times with one-minute intervals and at each time you will mark the highest point again. Keep your shoulders straight. Undercut and jump. Use both hands and legs to help you jump up high. Do you understand what to do?" The girls took turns to carry out the test. They did not learn their jump heights after the first round (they could see only marks without measurements). Participants were believed that this exercise is part of the team performance testing. Head coach of the team informed them about the importance of the testing and appeal them to achieve best individual results in every try.

Figure 1 and 2. Wall seat position

Figure 3, 4 and 5. Maximum vertical jump

Research questions:

1. How does the exercise in a group effect performance of synchronized swimmers at the age of 9-11?
1. What are the differences in the influence of this effect on various types of performance (isometric strength, dynamic strength)?

Results

The age range of the subjects was M=10.02±0.66 (n=14). Physical performance data did not come from normal distribution (Kologmo-Smirmov test). Wall seat position results were recorded in tab. 1. The mean performance in individual tries in this test was M=107.07±72.18 and M=216.21±140.47 for the group one. Vertical jump results were recorded in tab. 2

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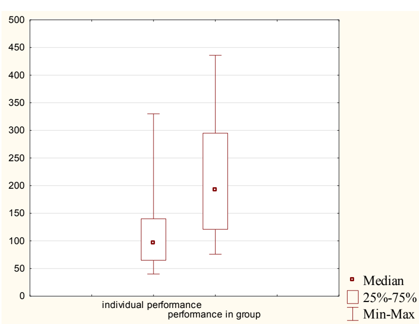
Table 1. Wall seat position results, differences and differences and changes

No.	Individual time (sec)	Group time (sec)	Difference (sec)	Percent. Change (%)
1	65	76	11	+16.9
2	40	120	80	+200.0
3	109	238	129	+118.3
4	62	121	59	+95.2
5	47	295	248	+527.7
6	140	436	296	+211.4
7	105	419	314	+299.0
8	93	92	-1	-1.1
9	100	178	78	+78.0
10	87	126	39	+45.8
11	175	240	65	+37.1
12	197	124	-73	-37.1
13	330	411	81	+25.5
14	79	206	127	+161.8

Table 2. Vertical jump results changes

No.	Individual height (mm)	Group height (mm)	Difference (mm)	Percent. Change (%)
1	21	23	2	+9.5
2	22	20	-2	-9.1
3	23	25	2	+8.7
4	17	18	1	+5.9
5	18	19	1	+5.6
6	15	19	4	+26.7
7	17	18	1	+5.9
8	13	18	5	+38.5
9	12	14	2	+16.7
10	29	31	2	+6.9
11	14	17	3	+21.4
12	22	20	-2	-9.1
13	14	16	2	+14.3
14	24	25	1	+4.2

Note: The girls were divided into two groups. The first one started with the individual and the other one with the group measurements. The group results are separated by a line in the tables.



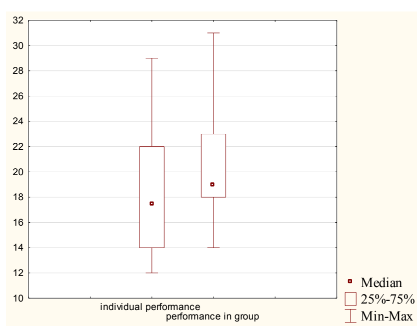


Figure 6. Mean value for wall seat position test / Figure 7. Mean value for vertical jump test

In the vertical jump test it was M=15.63±4.59 (individual) and M=17.19±4.61 (group). Further, we can see difference of mean values for individual and group exercise in the figure 6 and 7. The influence of social interaction was evaluated with the use of the *Cohen's d* which showed high substantive differences (dynamic strength d=0.33, small effect; isometric strength endurance =0.99, large effect). *Wilcoxon matched pair test* was used for data analysis. The results showed significant differences ($P<0.05$) between individual and group performance (isometric strength: Z=2.8563, p=0.0043; dynamic strength: Z=2.2913, p=0.0219). Results showed that exercising in the groups caused an improvement in performing both the vertical jump and wall seat exercise. Nevertheless, the influence of exercising in group was more evident at isometric strength. The differences between the times for each subject were converted to percentage changes (fig. 8). The mean percentage change in the wall seat position test was +126.8% (range -37.1% to +527.7%). In the vertical jump test it was +10.4% (range -9.1% to +38.5%).

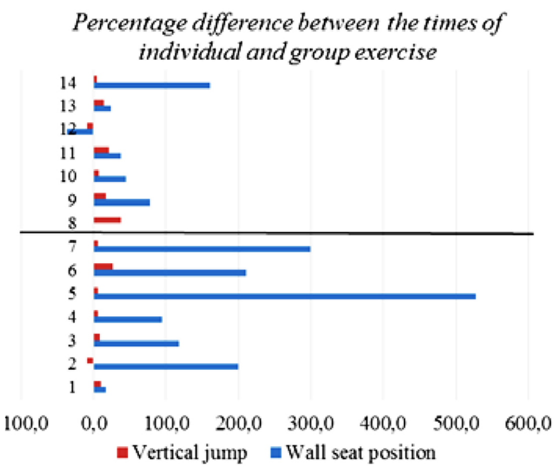


Figure 8. Percentage differences between the times for each subject

Discussion

The primary aim of this study was to determine whether the effect of group motivation gain could be harnessed to enhance children physical performance using a virtually present partner. The results showed there were differences in physical performance of children between individual and group tries, although the performance increase of some girls was not so noticeable (especially in dynamic strength performance). Köhler already described this phenomenon, when he found out the effect of two-person group on physical performance of the weaker one in the couple. He also overwrote than size of this effect depends on performance variance of group members. This motivation gain turned out the greatest when the stronger one from the pair was about 1.4 times stronger (Kerr & Hertel, 2011). In the group session of the wall seat test, it was visible, that the girls had finished the test in waves. The girls´ performance exercising in the group has improved many times, in one half of group. It took a long time than the first girl to finish off. Once one girl finished the exercise, several others joined her in the near future. The most evident improvement in our sample (wall seat position) was reached by girls, who were rather small, thin, or had a similar performance level in ordinary synchro training. Positive motivation benefit is also described by Osborn, Irwin, Skogsberg and Feltz (2012) who observed that swimmers swam faster in their relay swims than in their individual performances. But the main differences proved primarily at inferior relay swimmers. It is also interesting that the motivation gains were significantly greater in final relay than in preliminary swim. The authors further described a higher motivational effect in women than in men for both rounds (preliminary and final). Whereas, men achieved different results only in the final round, which, according to the authors, caused the importance of a task that mitigates motivation gains in men. Similar results have been described by (Weber & Hertel, 2007). In our results we can also see that higher differences appeared in isometric strength endurance (wall seat position) than in dynamic strength (vertical jump). Some girls in our sample have achieved better performance in the order of several hundred percent in a group-exercised wall seat position. The influence of virtually present partner on endurance performance (continuous aerobic exercise) was found out by Irwin, Scorniaenchi, Kerr, Eisenmann and Feltz (2012). Their results showed that cycling with more capable virtually present partner under coactive task (two riders were not on a team, i.e., no task interdependence) caused more than a 9.14 min (86%) increase in individual exercise. A further increase in performance was due to presence of a partner in the conjunctive conditions (they had the team's score). The subjects were cycling for about 19 minutes (208%) longer than in an individual task in the final trial with conjunctive participants. The influence of group motivation gain is not well described in youth athletes.

Conclusion

To sum it up, we found out that children´s physical performance could be affected by social interaction, i.e. mutual encouragement in a group. However, the effect fluctuated in the chosen sample. We can also see the different influence of group exercise on isometric and dynamic strength performance. We suppose that this difference is due to the distinct nature of performance. The results suggest that this effect is more important for children in exercises that children do not enjoy and have to overcome some degree of discomfort or pain. It could be assumed that group exercise is beneficial for the children training as well as other factors like positive verbal motivation, constructive feedback, and appraisal, of course.This could be a proper way to increase enjoyment and quality of training in individual sports and to motivate them to a higher effort during workouts.

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COMMON ELEMENTS OF SOCIALIZATION IN SPORT – A SUMMARY THROUGH THE CAREER TRANSITION THEORY

Šimková Katarína
Faculty of Sports Studies, Masaryk University, Czech Republic

Abstract

Purpose: Socialization in sport is an important aspect of individual stages of career transitions (Stambulova & Alfermann, 2007) recognized by three studies (continuation through bachelor, diploma and dissertation thesis).

Methods: The study is of a qualitative nature. The data was collected through semi-structured interviews and the analytical procedure described and established by The Grounded Theory (Strauss & Corbin, 1999). Studies were conducted with different age categories of athletes (15-18; transition from junior to senior stage, 20-30; active athletes, 35 and more – retired). The research was done with team sports as well as individual ones because the participants' opinions do not differ significantly between different type of sports or genders.

Results: The common elements of socialization are aspects of the group (acceptance, recognition of different personality types, recognition of self through eyes of the others, communication, cooperation); player intelligence; personality features (decision-making, autonomy, resilience and super vision); social support (friendship in sport and outside of sports); introversion versus extroversion, coach.

Conclusion: Positives of socialization in sport – in their own words – prevail; the negatives can be managed with the right approach. Significant and important elements are – approach of coach and close relatives and friends; their ability and interest in helping athletes to adapt to the environment outside of sports professional career.

Key words*: social support, player intelligence, career transition theory, acceptance, communication, autonomy; meaning of life, basketball; coach.*

Introduction

The socialization aspect of sport has a constant place in the research area, because socialization through sport has a strong influence on the individual who is involved in such activities. It monitors the skills; attributes, knowledge that are applicable in other areas of life. Such approach is also provided by Slepička et al. (2011), and in accordance to these results – based on the testimonies of the respondents – it is seen as a reality that cannot be overlooked in any kind of sport. The aforementioned characteristics learned by the sport influence the cognitive processes (way of organizing the team, social processes in the team). Coordination of performance in team will be improved through obtaining and maintaining a specific socio-cognitive state, called shared knowledge state (Eccles & Tenenbaum, 2007). The practice has proved that individuals playing in teamsports with excellent performance may not have high performance skills. Collaboration and communication is much more than individualities (Hagger & Chatzisarantis, 2005). Slepička (2009) states; cognition is related to the technical and tactical mastery of sportsperson. Empirical findings indicate that elite athletes are under-educated but not mentally absent; they could not climb into the top of the sports pyramid without adequate cognitive functions. The education itself is linked to a limited access to education of any type and to the lack of gaining typical working habits. The major role in competitions is played by endeavor, support and consistency (Hagger & Chatzisarantis, 2005). To build an efficient team, decisions must be made with all team members so they feel that the team belongs to them in particular,they must be convinced of the importance of their work (Slepička, 2009). Sport in general is an environment with a range of specific values and standards related to the rules applicable to the individual types of sports, which are often different from normal values and standards, and can modify this system of the long-term sporting individual; example isthe dimension of social identity. Sport is a very dynamic environment with a variable system of positions and roles, which creates prerequisites for influencing the athlete's own identity and managing a wide range of social roles in the socialization process (Heinemann, 1998). The sport identity, the level at which the player identifies himself with the athlete's role, and seeks confirmation of this role from others (Groff & Zabriskie, 2006). The other people (as socializing agents) are one of the three basic components of socialization in sport together with – the personality of the sporting individual and the social situation. First influencers of socialization are parents and their attitude towards sports, later in time – coaches and peers (Slepička et al., 2011). The personality of the athlete comes in contact with the various people and the environment that give him the fulfillment of the needs as is stated in Maslows´ pyramid (2000). The sporting career itself allows the fulfillment of basic needs and material security, other people inside and outside of sport provide fulfillment of the need of love and companionship, the need for self-respect through sport. These aspects can lead the athlete to self-actualization, which is often seen in sports. The Big Five theory by McCrae and Costa talks about the five basic qualities of personality (Leunes & Nation, 2002). Extraversion consists of such components as social, activity and tendency to experience positive emotions. Friendliness refers to an interpersonal approach. Neuroticism is associated with weak coping mechanisms that can lead to psychological stress. Consciousness speaks of such an individual who is well organized, pedantic, and hardworking. Openness to experience speaks about human creativity, its sensitivity, and flexibility in behavior. All the above-mentioned features stand out in sport.The meaning, sense of life is topic that also belongs to important factors of personality. Many athletes do sports because they see meaning in them.If they terminatethis activity, they may lose this sense. According to Frankl (1999), the world is objectively meaningful. There is meaning of small things (unobtrusive and trivial events in life, the meaning of which can be understood only later in life) and meaningfulness of the whole life (the central point of human existence, even though we can never grasp it fully). Those who do not have a sense of life can feel somewhat in existential vacuum. It may occur during the days afterathletes terminate their career (voluntarily and involuntarily). The development of the characteristics in the sport is also mentioned in the Krolls´ pyramid (Leunes & Nation, 2002). This model shows an interesting aspect, relating to both individual and team sports. At the beginning of the career, the athletes show heterogeneous characteristics, the closer they get to the elite sport, the more they express similar – homogeneous characteristics. Sports can also bring negatives - the development of antisocial behavior. An example is wrestling, which is characterized by verbal intrusion and deception. If such athletes are a role model for younger generations, they can have a negative impact on them as wellas their social behavior. It is recommended for inactive athletes to attend school, university matches because it can assist with identification with their local sports team, which can increase social life and therefore social-psychological health (Wann et al., 2015). The aim of this work is to look at the common elements of socialization in sport, helped by Gould and Dieffenbach (2002), whose aim was to reveal the impact of sport on the personal and psychological development of the individual. They summed up 634 references directly from athletes and described them in six important groups: 1. Community – individual and the environment that leads to certain experiences during adolescence. 2. Family – includes the whole family environment. 3. Individual development includes genetics, maturity, self-development. 4. People outside of sport – friends and teachers. 5. Sports people – agents, coaches, other top athletes, rivals, sports psychologists and teammates. Trainers help in personality growth, directly (mentoring, teaching psychic skills, teaching how to plan) and indirectly (enhancing desirable behavior, imitation). Sports psychologists offer the opportunity to learn positive attitude, consistency, offer different opportunities to gain new skills. 6. Sports Process – Specifics of the competition, sport itself, sporting nuisance, training, sports organization.

Methods

Methodology: A qualitative approach and grounded theories were chosen when selecting a strategy for data collection and analysis (Strauss & Corbin, 1999). The data were collected via semi-structured interviews.

Participants: Both men and women of three age groups participated; 15-18 (20 boys and 20 girls – main focus of dissertation thesis), 19-30 years (active athletes – 13; main focus of bachelor and diploma thesis), 30 and above (inactive, remaining as passive athletes – 4; main focus of bachelor and diploma thesis). Each category of athlete was in a different stage of his career (junior/senior stage, mastery stage, and final stage – career termination). Among the selected sports is mainly basketball, to a lesser extent football, volleyball, tennis, athletics, figure skating. Respondents are *from Slovak Republic* with *Slovak nationality*. The questions were developed on the basis of the individual stages of Career Transition Theory (Alfermann & Stambulova, 2007) from the beginning of the sporting activity through the junior level to the elite and the termination of the sports career.

Data collection process: An informed consent was sought before each interview (younger athletes had their legal guardians to give their consent); via a voice recording or signature. Respondents were obtained through acquaintances and official websites of individual clubs. The interviews were recorded in audio form using cover names and secure folders on the computer where they are stored. Individual interviews ranged between 2012 and 2017.

Data processing: Recorded conversations were transferred to the transcript. In all three cases, the data were collected and analyzed in stages to provide room for supplementary questions and possible reworking of interviews.

Data analysis: Open coding; the first step of the Grounded theory is the process of assigning a specific code/concept to each statement that reflects the meaning of the statements. These were categorized into higher significance units. The main concepts were selected through thematic analysis -working with information from the text itself (Braun & Clarke, 2006). The second step, axial coding, is to arrange the obtained information into other categories and subcategories. The last step selective coding – the work with the selected phenomenon; central category begins. The work summarizes the results of the three follow-up works, therefore the basic findings are presented in the following points – the pros and cons of socialization in sport and socialization by sport.

Results

The results are summarized in the main findings that affect the overall life of athletes, whether individual or team sports.

Positives of socialization – the benefits that sport brings, with some of them carrying a negative side. Both of them can interfere with the steady course of life of the athlete.

1 Acceptance. Since the beginning of the sports career, a player belongs to a particular social group, and can be identified with the group if necessary. It is one of the important elements of motivation in the sport during the first stages of a career - to have social support in sport, to have friends, be accepted, tolerated and respected both as a player and a personality. It represents the beginning of the creation of athletic identity, not only in the team but also in individual sports (co-operation with the coach or agent, managers, opponents, other players in the training process). *„It was weird, but girls came to help me, I fit into the team right away. It was... terrible but I was glad that I came, I never regretted it, team was awesome."*

2 Player Intelligence. Specific sports require a different level of game intelligence (high in basketball, volleyball). In this case, emphasis is placed on the importance of working not only with the teammates but also along the opponents - to read the game, to understand it, to predict. This aspect is shown also in the individual sports like figure skating, particularly during the training (athletes never practice alone in Slovakia). This teaches athletes cooperation but also influences decision making. *"There is no time to rest, you always need to have your mind switched on, you have to think and focus, because even the shortest moment of lost concentration is enough to make a change for results of the match."*

3 Different types of personalities can be studied and identified through the sports. In athletes own team, coaches, opponents, people outside of sport - athletes can transfer this experience to other areas of life, know how to deal with certain types of personalities, have more matured expectations. It can help to individual athletes to become more self-aware, they often call themselves selfish or egoistic (some of them must be if they want to succeed). *"To be 100% in everything. I don´t drink, don´t smoke, I eat normally healthy, everything."*

4 Extraversion versus introversion. Many athletes, not dependant on the type of sport, are not extroverts, social types of people. The world of sport often forces them to overcome this obstacle. Therefore, they have been able to develop specific mechanisms in the course of their career to manage these situations and thus to use them in other professions or in their personal lives. They can act as extroverts, but in fact they have learned to manage social situations so that they can develop further in their careers.*„And... uh, when you are in a team, you have to know how to work with people, any people, because when we were going on those representative travels, but I didn´t always went with my teammates, wanted.“*

5 Communication. This is an important element within all the points mentioned so far. We talk about teamwork, the relationships with the players, different coaches they meet during their career, the media - all these types of communication require a different level and style of expression. Inner speech and analysis ability also play a role - athletes are often taught to cope with their personal problems analytically, clarifying many of the problems within their own.*"Especially honesty, I hate if we talk about something behind our backs, there are misunderstanding and it seeps into the matches, there are problems that are not resolved, it can influence the game."*

6 Social support and relationships. Players usually find the most of their friends in the sport they are playing. They create their social support, which usually remains even after the end of their career (after leaving the team, the club, persisting friendships from childhood clubs). This happens for a strong shared experiences or shared emotions. They provide support (emotional but also informative), feedback from teammates or coaches. Relationships persist even after termination of career - they have someone to turn to, often across the country or the world. This aspect is also included among the negatives (described later). Sport reveals real friendships and family attitude - many people cannot accept the athlete's lifestyle choices, so they turn their backs to them and don´t support them.*„Sport gave me a lot of contacts and friends. I get to know people by traveling, meeting new people.“*

7 Attributes (decision-making, independence, resilience, and levity). Sport develops attributes that can be used in other areas of life, such as decision-making (especially in a new profession), independence at a very young age, resilience and oversight on life or problems, decisions that, together with communication, often require the conditions for admission to new professions.*"Then, then, of course, that some inner discipline, and so on, what I think… it remains, even after termination of sport, not doing it competitively."*

8 Coach – values, qualities (perseverance, goal, discipline). The coach is part of a team that should not only teach knowledge of the game but also certain values or attributes that sportspeople can translate into ordinary life (perseverance, purpose, discipline); draw attention to what's important in life, help with direction of their decisions, extend players view on life, show them something new that may be missing from their current perspectives.*"When we are not on the match, coach should be something like our second father. He should simply support us, tell us what we are doing wrong, not just in basketball but in other things. Not to drink alcohol, not to smoke, not to meet with these and these types of people."*

Negatives of socialization – negative consequences and possible impacts during sports career.

1 Friendships in sport. The problem may arise after leaving the team, country, sport as a career. Friends are often scattered outside of their home environment, so they may miss direct social support from them. Respondents said they were trying to have friends outside of the sporting environment, but it was not that easy (for different work and leisure habits). At the same time, it is challenging to build a family, to find a partner who will be willing to adapt for their specific lifestyle.*"It's probably not as same as it used to be, but ... we're still in contact and ... that stays for whole life."*

2. Introversion versus extraversion. If athletes fail to adapt (especially team sports), there is a risk of ostracizing, leaving the team, as players cannot find a way around, understand each other, which is often transferred to the game itself.*„At the start it was like... you play some sport, I wanted to try it and it was like... guys started to talk with me more, we started going out, to the cinema, I found myself a best friend between them, we visited each other, had sleepovers, guy stuff and so on."*

3 Attributes. They are mostly positive, but there some obstacles may occur in a new profession unless the athlete can adapt to other conditions. Successful sportsperson can experience anxiety and failure if he or she is not capable of achieving such successes as in the sports career where they belonged among the elite.*"And I wanted to be the best. I always wanted to be the best, before and now. I'm the best, and I'll be the best, I always wanted to win."*

4 Loss of sense. Many athletes, after career termination, have a problem with a different lifestyle because their sport has taught them certain habits that are not natural in our society. This may occur at an earlier age (15-18 year old). They invest everything in their sport, they live through the sport, develop an athletic identity that doesn´t end with the termination of their career, and therefore the adaptation may be slow and difficult. They become accustomed to overcoming them by focusing on other sports, training, or leisurely pursuing any sport. *"Well, when I happen to have a period of time that I do not play, I don´t know, well, I'm so ... maybe even at home, what I know, I am more nervous, I am not acting like myself."*

5 Independence. Athletes are a too often thrown into the outside world without any help at a very young age. They must learn language quickly, adapt to other cultures, and handle much more burdens than their peers.*„We were flying to Australia, two girls by ourselves, we were 17 years old. So, uh, I had to take care of myself. We did not get our luggage, we had to buy something, eh, then we had to deal with stuff, and then the languages of course, then, eh."*

6 "Normal people". Athletes are not seen as normal people, respondents themselves used this word. It's not just physical differences. They lack habits for job environment (working hours, free weekends, other types of authority and work); they have to go on without certain benefits (diet, doctors, handling essential documents) and deal with things they did not have to worry about before. When coming into the ordinary life, they might have a problem to get used it, they have to learn new habits and customs. All of this can be closely linked to the loss of a sense in life.*"For those normal people, who have not been living through sport, something hurts him and he does not know why."*

Discussion

Individual and team sports have impact on socialization process in a number of similar elements, as mentioned in the results. These are recurring aspects with both men and women, both senior and junior categories. *Krolls´ Pyramid* (Leunes & Nation, 2002) that talks about attributes – seeing more heterogeneous characteristics of the athlete at the beginning of his career and more homogeneous characteristics at the elite stage. Based on the testimonies of athletes, this can be attributed to the socialization process of sport that doesn't depend on the type of sporting activity – provided that adequate rules, values and norms are followed. Homogeneous properties can be considered as purposefulness, perseverance, autonomy, responsibility, discipline. These qualities are necessary for starting with sport and staying in sport, its´ development, sustaining them. Transferring them to the next life stage is possible, but it is a matter of the athlete's own work with the help of family and coaches, friends and teammates. If there are missing adequate rules, values and norms, negative characteristics could develop, which in this case was not confirmed (this may be a consequence of the chosen types of sport for research). Every contact sport can be met with aggressiveness, which is understood as part of sport, but still playing with clearly defined boundaries of moral behavior. The most significant negative are the missing habits for ordinary life after the career. Take care of themselves in areas that are usually solved by their agents, managers, parents (medical care, office equipment, financial control, work habits). It goes without saying that the sport profession also requires specific habits, based on a different time management than in the classical professions (weekend competitions, weeklong training sessions, different schedules than working from 7 to 15). This element should be captured at the early stages of sporting career, through the influence of a coach who doesn´t have to only teach game knowledge but also knowledge of life. The attributes of an athlete, people around him, and the environment in which the athlete works, are areas described by Gould and Dieffenbach. These play a strong role in the life of an athlete, and these three elements are ranked among the basic components of socialization (Heinemann, 1998). Second factor is environment – in this case Slovak Republic. The chance for professional sport is narrow, particular importance is the preparation for further living. Third factor are people - family, friends, relatives and coach. Teammates, another athletes in coaching, and coaches themselves shape the individual with influences on each other. The coach represents specific authority, something like the other parent, so his impact isn´t negligible. The personality relates to the predispositions of the individual who is starting with chosen sport discipline. Without many of them, the athlete might not be able to continue playing. The question is whether these qualities would develop in another profession, or as quickly as they develop in sport setting. It is important how much the athlete can transfer these attributes to other life domains; apply to them in school, at home, in other professions. Nevertheless, these results confirm other studies that talk about sport being able to – strengthen internal discipline, develop courage, persistence, resistance to the burden. Sports are for children means how to gain communication skills and skills applicable to decision-making processes (Drewe, 1998 & Krane, 1998). When looking behind the imaginary veil of sport and the attributes it can develop, we can look at the theory of Seligman (Smékal, 2012) certain virtues, graces: the bravery in overcoming obstacles (the will to achieve goals, perseverance, integrity), justice – a fair approach to society (teamwork, accountability, honesty), humanity – the ability to create good relationships outside of the playing field (love, social integrity), modesty – working on yourself and your personality, realizing the "specialty" of your place and role (modesty, self-control) , transcendence – finding meaning in the sport and what can be used in other areas (sport, self-actualization, beauty appreciation), wisdom and leadership – the ability to learn what other areas of life do not allow in a specific way (creativity, openness , wisdom – development by sport). Respondents clearly agreed that they want give everything they learned to others -either to new generations or to their loved ones and acquaintances. They recognize the importance of sport despite some negative aspects. It is important to recall that in the case of this study we are talking about individuals whose sport did not disappoint them. The idea of shifting knowledge and experience goes hand in hand with the concept of generativity by Erickson (1999). It is the period of gaining certain wisdom and moving it further. In the sporting profession, it is at the stage of the mastery or at the stage of career termination – which is before the middle age of people.

Conclussion

The sporting career cannot be seen as an environment that brings only positive, but with adequate attitude, right values and advices, the athlete can quickly adapt to the negative, or learn certain mechanisms how to handle these negatives. Therefore, it is important to approach socialization in sports cautiously and as a whole, especially where there is a chance to become professionals (especially for those who will be lucky). It depends on the chosen sport and the environment, or part of the country where the individual lives. Therefore, it is important to know the family the individual comes from, the community in which they grew up, other players he / she comes into contact with. The coach should try to get to know each of them and, if necessary, bring different degrees and types of wisdom. It should also create an adequate training environment that includes space for education. If parents, friends, and coach know the personality of an athlete, who he really is, they can work with him gradually, influence him, help him to develop further (directly and indirectly). Socialization in sport is risky if isolation occurs. There should be a certain compromise, the duality in the development of the individual, so that after the end of the sporting career he does not come to a society that he does not understand and cannot adapt to, because he lived only inside of the chosen sport.

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THE VOLUME AND INTENSITY OF MOTORIC LOAD OF PRIMARY SCHOOL CHILDREN IN THE IMPLEMENTATION OF INTEGRATED FIELDWORK EDUCATION

Trávníček Marek, Svobodová Hana, Gyurjánová Tereza, Durna Radek
Masaryk University, Faculty of Education, Brno, Czech Republic

Abstract

This paper focuses on children´s physical activity during the school day. It also deals with the integrated fieldwork as one of the forms of teaching and its possible influence on the children´s physical activity throughout a school day at primary schools. In the research we analysed each method of teaching in terms of the number of steps the pupils made and their metabolic rate. The minor aim was to verify the use of ActiGraph accelerometers by teachers at schools and to provide basic information about the devices to the potential users. The paper compares three types of school day, i.e. a day of frontal teaching, a day comprising a physical education lesson, and finally a day where integrated fieldwork education (IFE) is implemented. Each type of day is analysed in terms of the number of steps the pupils made and the metabolic rate in MET units. The physical education class had the highest volume of movement – 1,202 steps in 45 minutes. However, the IFE with 1,118 steps in 45 minutes may be compared to a class of physical education in terms of the number of steps. The weakest in terms of the steps made and the amount of physical activity was a habitual education class, where students walked an average of 218 steps in 45 minutes. We also tried to find out the intensity of the physical load of pupils of early school age. Again, the physically most demanding form of teaching was the physical education lesson, during which pupils achieved medium physical load above 3 MET. For integrated fieldwork education, the metabolic output was below 3 MET, namely 2.63. The lesson of habitual teaching was characterized by a low intensity motoric load of 1.81 MET. The research results in IFE being significantly more physically demanding than a habitual class, and being comparable with a physical education class.

Key words: *ActiGraph, accelerometer, children physical activity, metabolic rate, motoric load, school day, fieldwork, integrated fieldwork education*

Introduction

This contribution focuses on the issues of movement, more specifically on the movement activity of early school age pupils and physical load of children during a school day. Both in this country and worldwide, many authors applied themselves to movement routine of pupils in their research. Mužík (2007) recommends 30 minutes of a lower intensity movement activity a day, to which 30 minutes of medium intensity movement should be added at least 3 times a week. As compared to Mužík, the demands of Mr. and Mrs. Sigmund (2011) for the daily movement activity of early school age children are significantly higher. In their opinion, the medium intensity daily movement activity of children should be 3 times longer, i.e. 90 minutes. Adequate volume of daily movement activity serves for maintaining aerobic prowess in children. Frömel (1996) states that during physical education lessons at school pupils can fulfil the minimum motoric load, provided responsible personnel and adequate conditions are secured, although this can be arranged also in other than physical education lessons. In addition to physical education at school, early school age children can come close to the minimum motoric load within various free-time activities during the day. The selection of extracurricular activities often depends on the choice made by parents, who may not support movement activity; hence if a child does not attend any interest group aimed at sport or physical activity, the minimum motoric load can be compensated with physical education lessons at school at the least. Parents often rely on that, although it doesn't make the volume of movement activity for children of early school age adequate either.

It follows from the above that it is advisable to increase the percentage of movement in pupils, and by means of various physical activities to support their interest in movement already at an early age, both in the school environment and beyond the designated physical education lessons, for example by integrating the individual school subjects precisely with physical education. For these reasons progressive, activating forms of teaching, like for example integrated fieldwork education, present themselves. Through fieldwork education, it is possible to achieve natural implementation of movement activity directly into the instruction of various subjects. Connecting movement activities with the educational content of various subjects is supposed to have positive effects on the motoric routine of basic school pupils (Trávníček, 2010).

Průcha (2013) characterizes integrated education as teaching implementing cross-curricular relationships and connecting theoretic activities with practical ones. This education takes place mainly in the forms of integrated subjects or courses, modules or themes build into more subjects, projects linking the findings from several subjects with practical experience.

According to Korvas and Cacek (2009), introduction of the integrated curriculum into the FEP BE enhances the option to implement teaching programmes of various subjects with movement activities. Podroužek (2002) states that in the newly conceived curriculum, the content of the curriculum is outlined on the grounds of integration of various educational subjects into the so-called educational spheres, for instance Man and the World, Man and Nature, Man and the Society, or Man and Technology. Integrated curriculum makes it possible for pupils to get to know the world as a whole, and Průcha (2013) advances the point that this type of curriculum is traditional especially at the primary grades of basic schools.

Integrated teaching of various subjects with physical education or movement activities is a relatively new concept in the implementation of educational process in our schools. Its novelty consists mainly in the relative scarcity of previous experience, incentives, and research in this sphere in our country. It is an endeavour after breaking well-established processes and enhance them with innovative approaches. The first move in this sphere in our country is international cooperation in researching the possible integration of physical education and geography (Vlček et. al 2016).

The use of authentic environment for instruction presents itself in the course of effective introduction of integrated teaching. In the transfer of integrated education beyond school desks – into the field, we automatically achieve integration of movement activity into teaching, while we also obtain a natural environment for the integration of the other subjects. In so doing, we afford the pupils a clearer outlook of the content of the curriculum and an easier understanding of the relations among the individual branches. Therefore, we encounter with the term fieldwork education. In foreign countries, fieldwork education has been considered a very powerful teaching strategy for many years, both for understanding the today's world (see e.g. Balderstone and Lambert 2012, or Oost et al. 2011) and for the development of the key pupil competencies – for learning, problem solving, social, personal, and communicative competences. It is specific for a number of scientific and humanitarian disciplines, but the connection with physical education is also logical.

According to Hofmann (2003, p. 7), fieldwork education is a complex form of instruction that encompasses various teaching methods (experiment, laboratory tasks, observation, project method, cooperative methods, adventure educational methods…) and various organisational forms of instruction (outings, field exercises, excursions, thematic school trips – expeditions), while the focus is on the work in the field, primarily out of the school. The contribution follows on a long-term successful practice and a research related to integrated fieldwork education, especially at the Faculty of Education MU (Hofmann, Trávníček, & Soják, 2011; Korvas 2009), where investigation has proven that fieldwork education is an equal form of school teaching, and it can have a major share in integration of either two or more subjects.

Therefore, integrated fieldwork education appears to be an effective form of teaching, in which subject matters of various subjects become connected with movement activity in the field, i.e. outside the school building.

Integrated fieldwork education is outdoor teaching, in the course of which we employ the subject matter of several teaching subjects and the methods typical for these subjects of study in such a way that the resulting compact teaching makes the pupils develop in the social, personal, and cognitive sphere. Cognitive learning or acquiring information on the world, recognizing the relations among individual subjects, and their subsequent application in practice can take place both in the classroom environment and during work in the field. Motoric teaching, however, is very seldom the content of the educational process in the classroom. If this is the case, it more likely happens at the level of fine motor skills development. Often we are unable to secure gross motor skills, prowess, stamina, and other movement skills when teaching in the classroom; hence especially physical education lessons serve for the development of this constituent of personality. Nevertheless, if teachers transfer teaching from the classroom outdoor, into the natural scenery, they have much more space and options to implement motoric learning. Integrated fieldwork education offers a wide scale of spheres teachers can develop applying this form of teaching even beyond physical education lessons.

The objective of this contribution is to ascertain and compare the physical load in early school age children during three types of school days, namely a classic day, i.e. without a physical education lesson and outdoor instruction, with a habitual character teaching; a day comprising a physical education lesson, and a day with integrated fieldwork education.

The measured quantities are the metabolic rate in MET values and the number of steps. The partial goal of the work is to verify the use of ActiGraph accelerometers in monitoring the physical activity in early school age children in the school environment, and to provide basic information on the functionality of measuring children using these devices.

Methods

The objective of the research was to ascertain the intensity of the physical load in early school age pupils attending a selected basic school in Brno in various forms of teaching, namely a habitual education class, teaching comprising a physical education lesson, and integrated fieldwork education. The acquired data were compared in the form of case studies for individual pupils. Intentional selection was applied to choose the pupils of the 4th form at one of the university schools of the Faculty of Education, Masaryk University in the period from January to May 2016. Because of the limitation imposed by the number of monitoring devices to be used for the research, our sample contained 10 probands out of the total number of 24 pupils in the class. The ten probands were determined applying stratified sampling. The core set was divided into two groups for equal representation of boys and girls in the sample, therefore it comprised 5 boys and 5 girls. The physical load in early school age children was monitored using ActiGraph accelerometers. Out of the functions these instruments can measure, in our work we concentrated on the number of steps in the selected forms of teaching, pulse rate, and metabolic rate in MET[11] units, where 1 MET equals to energy cost in passive sitting position. Measurements were complemented with structured interview to find out the teacher's opinion regarding the monitoring of physical load of her pupils using accelerometers, and especially the possible limitations on the pupils resulting from wearing the devices during various activities. The second observed sphere was the incorporation of integrated fieldwork education into the teaching of the respective class, and the content of integrated fieldwork education.

To find out the attitudes of children towards the convenience in wearing the instruments and outdoor teaching and the interest of children in this non-traditional form of teaching brief questionnaires were created to make the information on measurement complete. The measured values of number of steps and metabolic rate in MET units for the same time interval in individual probands were averaged and compared in a table. The measured data from all habitual education lessons, i.e. altogether 12 data from 3 days of measuring, were averaged to create a representative lesson of this form of education for each pupil separately. The same method was applied in processing of results obtained during integrated fieldwork education. The data for all breaks were averaged at the number of steps per 1 minute and subsequently multiplied by 45 to provide relevant results.

Results

The interview with the class teacher was carried out towards the end of investigation, after the implementation of fieldwork education. It was clear from her answers that the monitoring devices put no limits on her preparation for teaching, and she felt no major limitations during her teaching either. In her responses the teacher also corroborated the above advantages of fieldwork education, specifically adventure learning, due to which subject matter can become strengthened in pupils more easily.

The questionnaire was distributed to pupils participating in the research after the termination of all measurements. It follows from the outcomes obtained from the pupils by means of the questionnaires that initially half of the pupils had problems with attaching the instruments, and they needed to be helped by an adult. Sixty per

11A MET is the ratio of the work metabolic rate to the resting metabolic rate. One MET is defined as 1 kcal/kg/hour and is roughly equivalent to the energy cost of sitting quietly. For example: the energy cost of playing rugby is 8.3 METS, which means you use 8.3 times more energy than if you were to sit quietly and rest (METS, 2016 online) cent of children designated the upper chest belt as less comfortable. After resetting and adjustment of the belt especially children with smaller chest girth designated the belt as uncomfortable, although it was not a limiting factor in the teaching. The questionnaire also dealt with the implemented integrated fieldwork education. Eighty per cent of pupils unambiguously answered they found fieldwork education entertaining, and its effectiveness was verified using the so-called film strips, when pupils in art lessons recorded the subject matter (development stages of frogs) in the correct sequence within a twelve-day lapse of time from outdoor teaching. The monitored pupils created the correct development cycle with all important stages; hence it can be stated that during the implementation of integrated fieldwork education no deterioration of results of learning occurred.

Average measured data relating to the individual lessons, namely a habitual education class, physical education lesson, and integrated fieldwork education are presented below. The table below (Tab. 1) indicates the average numbers of steps obtained from measuring all of the 10 probands in selected lessons during 45 minutes of the teaching in question.

Table 1. Comparison of the average number of steps during selected lessons

	Habitual education lesson	**PE lesson**	**IFE lesson**
Number of steps	218	1 202	1 118
Max no. of steps	364	2 020	1 160
Min no. of steps	116	673	800

It is evident from the average values that the number of steps during integrated fieldwork education is more than five times higher than during habitual teaching. If we consider an integrated fieldwork education lesson and a physical education lesson, however, we have to state the difference of nearly 100 steps in favour of the physical education lesson. Because of the total number of steps, it is possible to state that from the point of view of the movement activity volume these two forms of teaching are almost comparable. As against the physical education lesson, a doubtless advantage of integrated fieldwork education is the transfer of specialist subject matter to the pupils (at the 1st grade most often national history and geography, natural science within educational sphere Man and the World).

The table below (Tab. 2) presents the measured values of metabolic rate. Average values obtained from all pupils participating in the research are presented.

Table 2. Comparison of average values of metabolic rate during selected lessons

	Habitual teaching	PE	IFE
Average metabolic rate (METs)	1.81	3.46	2.63
Max metabolic rate (METs)	6.64	8.10	7.73
Min metabolic rate (METs)	1.00	1.00	1.00
Median metabolic rate (METs)	1.80	3.23	2.45

The following diagram (Fig. 1) illustrates the average values of motoric load in all probands recorded in the individual types of teaching.

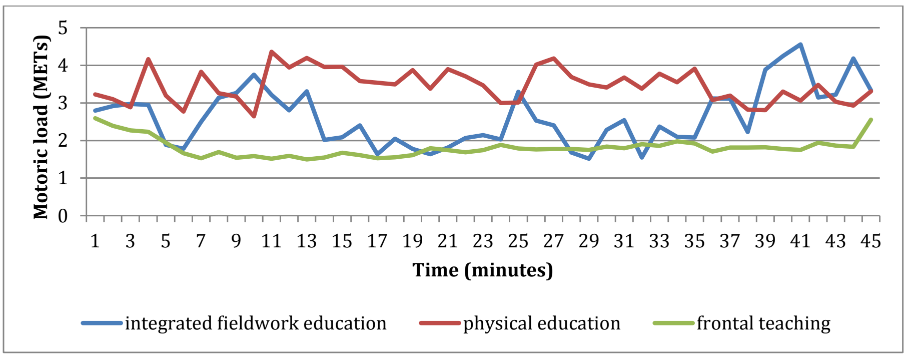

Figure 1. Behaviour of the average values of motoric load in all probands recorded in the individual types of lessons

If we compare the individual lessons on the grounds of average metabolic rate, we conclude that during IFE average values increase, but so do the maximums as against a habitual lesson. An average intensity of motoric load during integrated fieldwork teaching, however, ranges between the average value of metabolic rate of a habitual lesson and a physical education lesson; therefore, in comparing IFE with a PE lesson in our research the physical education lesson comes out as better. Since there is a number of ways how to conceive integrated fieldwork education, depending on the contents, but also the environment where it is performed, quite possibly the reason of obtained outcomes is exactly the uniqueness of the integrated fieldwork education we implemented within our investigation.

If we consider an average school day consisting of 5 lessons, of which 4 lessons are devoted to teaching of a habitual character and the remaining lesson is always one of the monitored lessons, the comparison of the individual types of days, i.e. a day with a habitual education lesson, a day with a physical education lesson, and a day with integrated fieldwork education, is consistent with the comparison of the individual forms of teaching. For the pupils of the selected school in Brno the most beneficial type in terms of movement activity appears to be the day comprising a physical education lesson; nevertheless, integrated fieldwork education is a comparable substitute to the physical education lesson. If we ensue from the division of outdoor education from the perspective of time after Hoffman (2003), IFE should take at least two hours. Therefore, in case we implement two lessons of integrated fieldwork education in a school day, this type of day would be more beneficial for the selected pupils in terms of movement activity, as stated in the table below (Tab. 3).

Table 3. Comparison of the individual types of days from the perspective of number of steps and metabolic rate

	Day of habitual teaching	**Day with a PE lesson**	**Day with an IFE lesson**	**Day with two IFE lessons**
Number of steps	1.090	2.074	1.990	2.890
Average metabolic rate (MET)	1.810	2.140	1.970	2.640

It follows from the stated data that integrated fieldwork education and a physical education lesson alike increase both intensity and volume of movement activity within a school day, and it is evident that IFE of a longer duration has a very decisive impact on the motoric load of the pupils.

Discussion

Looking at the results of the research we can state that a lesson of integrated fieldwork education is almost equal to a physical education lesson in terms of movement activity measured by means of number of steps. In their book of 2009, Korvas and Cacek of the Faculty of Sports Studies, Masaryk University indicate that for pupils of the 2nd level of basic school a lesson of integrated fieldwork education is comparable to a physical education lesson in terms of number of steps. Therefore, we can say we have extended the conclusions of the above scientists to also include the selected pupils of early school age. With the low quantity of probands and an absence of a deeper analysis the obtained results cannot be generalised, although the measured data allow observation of certain tendencies that corroborate our assumptions regarding the volume and intensity of movement activity in the school environment.

Since integrated fieldwork education comprises two constituents, motoric and educational, there are many different concepts of this form of teaching. Therefore, in drawing these conclusions it is necessary to bear in mind that the two types of lessons (integrated fieldwork education and physical education) may not always meet the measured data. Additionally, it is important to realise that knowledge, hence the effectiveness of IFE, is an equally important constituent of this form of teaching as its motoric component. Therefore, the motoric constituent should never surpass the educational one.

From the perspective of physical load intensity, the values achieved during an average outdoor lesson range exactly between the values measured during a habitual lesson and a physical education lesson. Therefore, integrated fieldwork education is a form of teaching with a greater motoric intensity than a habitual lesson, and at the same time no deterioration of results occurs during IFE.

Conclusion

The objective of the research was to compare three types of school days, which differ in the application of various forms of teaching. The forms we included into our investigation are habitual education, physical education, and integrated fieldwork education. Selected lessons were compared from the perspective of movement activity volume, i.e. the number of steps made by individual probands and their metabolic rate, i.e. the amount of motoric load. ActiGraph accelerometers were used to measure these parameters.

The average highest number of steps was achieved during physical education lesson; contrariwise, habitual education lesson resulted in the lowest number of steps. Furthermore, we tried to ascertain the physical load intensity amount of teaching the early school age pupils. Again, the physically most demanding form of teaching was physical education lesson, the integrated fieldwork education lesson was somewhat less demanding, and habitual education class was characterised by a low motoric load intensity. All types were completed with the description of strengths and weaknesses of measuring using ActiGraph instruments. To this end, a questionnaire was created and an interview made with the class teacher, complemented by our experience with the instruments. A doubtless advantage of the ActiGraph instruments is an easy handling with the devices, i.e. their setting prior to both measuring and upload of data; each investigator should become thoroughly acquainted with this beforehand. The main drawbacks of measuring using these instruments include the manner of fastening, or the discomfort caused by the fastening belts and their inappropriate length, or an inappropriate length of the belt for measuring of early school age pupils and delicate children.

Implementation of movement activity measuring is not based only on the need to prove inadequate movement activity of school age pupils, but also on the need to strengthen the role of (integrated) fieldwork education in the Czech schools. Whereas foreign research in the sphere of outdoor teaching have already proven the positive impacts of fieldwork educational activities on teaching (Neil, Richards 1998), described the factors hampering the implementation of outdoor education (Waite 2009), or dealt with the importance of fieldwork education for cognitive and affective development of pupils (Mygind 2009), in the Czech Republic this research has only just started within the Czech Science Foundation project "Fieldwork Education as a Powerful Teaching Strategy" (GAČR 16-00695S Fieldwork as a powerful learning strategy). Thus far there is no coherent awareness of incorporating fieldwork education into school curricula or the real implementation of outdoor education at basic and secondary schools, and for instance its influence on the movement activity and healthy lifestyle was studied only marginally (Korvas 2009).

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USE OF INTRINSIC MOTORIC IMAGINATION ON THE LEVEL OF MUSCULAR STRENGTH; METHODOLOGICAL STUDY

Trochta Pavel, Válková Hana,
Masaryk University in Brno, Czech Republic, Faculty of Sport Studies

Abstract

This paper attempts to share experience of the process of methodical crystallization in study related to use of intrinsic motoric imagination as a method of increasing level of isometric muscular strength contraction of handgrip muscles. This project comes under neuromuscular field of science. Researches dealing with direct "mind to body" impact are rather rare and struggle with methodical concepts or interpretation of results very often. Therefore, this study is trying to pass on my experiences gained in the process of formulating methodical procedure to show an example how to form methodical procedure in little mapped scientific field.

Compared with research findings I summarized aim of project into four main areas: selection of nature of population and form of getting feedback information during research; selection of muscle group and appropriate measuring instrument; how to explain and teach imagination skills to participants and develop suitable imagination training program; selection of the most appropriate brain activity displaying method. *Results*: 50 (20 to 30 years) non-athlete men are assumed as suitable sample. Each participant should fill imagination training feedback information in special questionnaire every day. Handgrip muscles are considered as an appropriate muscle group. This group of muscles are used on daily base on certain level of activity. Therefore it should be more resistant against accidental workload impact. This study suggests organising 1 to 3 common lectures. Common lecture includes basic information about use of imagination and its limits, explanation how to concentrate on image of working muscle properly and getting familiar with isometric handgrip muscle dynamometer.

FMRI is considered (functional magnetic resonance) as a most appropriate brain activity displaying method. Each Participant takes part in 3 measuring (1 before training program, 1 after 4 weeks and 1 after training program – 8 weeks).

Key Words: *Intrinsic Motoric Imagination (IMI), Extrinsic Motoric Imagination (EMI), Concentration, Neuromuscular study, Handgrip muscles group, Mind, Imagery training, Muscle contraction, functional magnetic resonance (fMRI)*

Introduction

Connection between mind and body is studied since ancient times. Nowadays, we can allow observing many aspects of this relationship. Mental training is psychological way of mastering human mind. From one point of view mental training changes way of thinking, perception and regulates affectivity (Slepička, Hošek & Hátlová, 2009). On the other hand perspective of mental training shows up mainly in utilization of methods. These methods encompass for example self-talk, modelling, visualization or mental imagery (Tod & Lavallee, 2012). Mental imagery is a specific mental process involving multisensory experiences in the absence of actual perception (Murphy, S., Nordin, S. M., & Cumming, J. 2008 in Tod & Lavallee, 2012). Specifically in sport, motor imagery can be understand as a dynamic state during which a subject mentally simulates a given action (Decety, 1996). From my point of view, if we look at contemporary mental imagery practise we will notice that it can be distributed into two main areas. Mental imagery used as mind to mind method or mind to body method. In first case, Imagery enhances mental skills such as concentration, mental memory or relaxation which subsequently impact physical execution of particular motion. This attitude includes 5 divisions. Cognitive specific, cognitive general, motivational specific, motivational general arousal and motivational general mastery (Paivio, 1985 in Tod & Lavallee, 2012). However, there is gradual evidence of direct mind to body imagery impact. Following studies deal with influence of mental imagery on muscular strength including muscular strength of elbow flexion, little finger abduction or hip flexion (Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004; Shackell & Standing, 2007; Reiser, 2011; Yao, Ranganathan, Allexandre, Siemionow, & Yue, 2013). There is only one evidence, which did not prove relationship (Herbert et al., 1998). Although, most of results of these studies pointing out that the effects of mental imagery are obvious, there are many other aspects which we still do not understand. For instance, we are not able to explain the effectiveness of mental imagery mechanism (Eiichi Naito et al., 2002; Reiser, 2011). All in all, this field of study requires substantial knowledge of human kinetics, psychology and neurophysiology. This considerable complexity can also lead to uncertainty in the development of methodical design. Therefore it is essential to ask following questions. Should we ask athletes or non-athletes to participate? Should we measure muscular strength of muscles which are continuously used during daily life or should we concentrate on minor specific muscles? How can we monitor the process of learning and using motor imagery? And last but not least, what are the limits?

This paper attempts to share experience of the process of methodical crystallization in study related to use of intrinsic motoric imagination as a method of increasing level of isometric muscular strength contraction of handgrip muscles. In this study I describe the process of methodical crystallization and propose suitable design consisting of 4 parts – selection of nature of population, selection of muscle group, imagination skills training and brain activity displaying method selection. Further, I substantiate my steps considering current research and my own experience. Overall, purpose of this study is to offer helpful tool for further research in this field of study.

Research

Selection of nature of population

Although, majority of research use mixed population (Clark, Mahato, Nakazawa, Law, & Thomas, 2014; E. Naito & Ehrsson, 2001; Reiser, 2011; Siemionow, Yue, Ranganathan, Liu, & Sahgal, 2000; Yao, Ranganathan, Allexandre, Siemionow, & Yue, 2013), it should be taken into account mutual differences between men and women. Biological and psychological aspects differ significantly. Men are generally focused on performance which usually sets their aspiration on high level. Compared to that, women tend to prefer stable emotional relationship as a priority (Slepička et al., 2009). Because cultural and social background educate young men to hide or overcome their own emotions (Slepička et al., 2009), I presume that men developed better ability to ignore other thoughts unrelated to mental imagery goal. I consider this ability as a potentially important factor. Nevertheless, it is important to mention, that most of researches brought positive results regardless of gender. Furthermore current researches often deal with different attitudes towards sports background. Some researches prefer participation of athletes (Reiser, 2011; Shackell & Standing, 2007), but the most do not define specifically (Clark et al., 2014; Herbert et al., 1998; Chiew, LaConte, & Graham, 2012; Luft, Skalej, Stefanou, Klose, & Voigt, 1998; E. Naito & Ehrsson, 2001; Eiichi Naito et al., 2002; Ranganathan et al., 2004; Siemionow et al., 2000; Yao et al., 2013). Though majority of researches brought positive results, researchers are rather careful with its interpretation. I understand this attitude. There could be many limiting factors waiting to be discovered.

Selection of muscle group

There is extensive variety of tested muscles. For instance, studies deal with little finger abduction (Yue & Cole 1992 in Reiser, 2011; Ranganathan et al., 2004), elbow flexors (Ranganathan et al., 2004), wrist flexors (Clark et al., 2014), bench press, leg press or triceps extension (Reiser, 2011). This variety is useful to its purpose. More positively tested muscle groups bring more reliability into mental imagery training. On the other hand selected muscles are rather specific or isolated. Based on research facts above, these muscles tend to react on mental imagery training intervention more and faster than "large muscle groups". From my own point of view, there could be three reasons for this phenomenon. Firstly, imagination of big muscle groups is more challenging due to its demand to concentrate on big and complex image. Secondly, large muscle groups are usually more often involved during daily life situations. So it can be assumed, that muscles are more resistant against moderate load. And lastly, muscles differ from each other specifically. Some muscles are adapted to power demands; others tend to excel in endurance (Hoffman, 2014).

All in all, it depends on the purpose of study which is essential for suitable muscle group choice. Nevertheless, I consider it very beneficial to extend evidence of studies which focus on non-isolated muscle groups. I suppose, that this is probably the way of exploration the limits of mental imagery.

Imagination skills training

*I*t has been shown that the main underlying mechanism for motor imagery training-induced strength gains is by adaptations occurring in the nervous system (Yao et al., 2013). Furthermore, there is vast evidence, that performance of a task and its imagination shares common neural substrates (Berthoz, 1996; Cunnington et al., 1996; Decety, 1996; Jeannerod & Decety,1995; Lang et al., 1996; Porro et al., 1996; Stephan & Frackowiak, 1996 in Luft et al., 1998). This phenomenon is often called motor activity-related cortical potential (MRCP) and is described as EEG-derived brain potential associated with voluntary movements (Siemionow et al., 2000). In mental imagery researches are two main attitudes of performing motor images. External (extrinsic) motor imagery (EMI) and intrinsic (internal) motor imagery (IMI). In EMI, also known as third-person visual imagery, the person sees or visualizes performing the task from outside the body—similar to watching oneself in a mirror performing an exercise (Yao et al., 2013). In IMI, also known as first-person or kinesthetic imagery, a person imagines or mentally creates the feeling of performing the exercise from within the body (Yao et al., 2013). Results of researches mentioned above suggest, that IMI is considered to be more effective. Nevertheless, some studies argue, that in case of IMI is adaptation caused by accompanying kinetic feeling more than by imagery itself. It turned out that motor imagery examination effect on kinesthetic sensation. However this kinesthetic effect appeared due to internal stimulus without any noticeable unconscious frail muscle contraction (Eiichi Naito et al., 2002). Based on available research, I suppose IMI more effective due to its ability to engage more senses. This connected sensory accumulation (at least visual and kinesthetic) may help to create more realistic and more convincing image of performed imagery moves. Last but not least, very important appears to be time framework of motor imagery training. See summary table below (Reiser, 2011).

Table 1. Mental Imagery Time Framework summary (Reiser, 2011)

	Small muscle groups			Large muscle groups			
	Yue and Cole (1992)	Smith et al. (2003)	Ranganathan et al. (2004)	Herbert and Gandevia (1998)	Zijdewind et al. (2003)	Ranganathan et al. (2004)	Reiser (2005)
Duration of one IMC (s)	15	5	5	10	10	5	5
IMCs per unit	15	20	50	6	50	50	8
IMC duration per unit (s)	225	100	250	60	500	250	40
Units per week	5	2	5	3	5	5	4
IMC duration per week (s)	1125	200	1250	180	2500	1250	160
Training weeks	4	4	12	8	7	12	4
Total IMC duration (min)	75	13.3	250	24	292	250	10.7
IMC effect (%)	22.0	23.3	35	6.8 ns	21.8	13.5	5.7

It seems that time of IMC (imagery maximal isometric contraction) per unit plays an important role. Furthermore total IMC duration (min) is also quite noticeable factor. Considered all other factors of effectiveness (see table 1), I suppose that IMC per training unit, total IMC duration together with IMI type of imagery are the most significant factors influencing overall impact of motor imagery training.

Brain activity displaying method selection

Based on convenient research evidence fMRI - functional magnetic resonance (Chiew et al., 2012), PET - positron emission tomography (E. Naito & Ehrsson, 2001; Eiichi Naito et al., 2002) and EEG - electroencephalogram (Siemionow et al., 2000; Yao et al., 2013; Ranganathan et al., 2004) belongs to the most suitable and exact brain activity displaying methods (connected with the purpose of mental imagery tasks). While EEG captures changes in electrical potential on the surface of the head, PET monitor changes in metabolism or blood flow. fMRI as a non-invasive method includes perfusion fMRI and BOLD fMRI. Perfusion fMRI uses a local increase in blood flow, called perfusion, at the site of neuronal activity. BOLD fMRI uses the change in the ratio of oxygenated and unoxygenated blood at the site of neuronal activity, which is referred to as the BOLD effect (blood oxygenation dependent). These methods differ from each other by spatial and time distinction ability. EEG offers the highest level of time resolution but poor spatial resolution. The disadvantage of PET is mainly exposure to radiation and poor time resolution. fMRI as a fairly new method brings relatively high spatial resolution and acceptable time distinction ability ("Funkční magnetická rezonance / fMRI Brno", 2004; Decety, 1996).

Results

Selection of nature of population

50 healthy non-athlete men (age; 20 – 30 years) from Faculty of Philosophy of Masaryk University will participate in this research. Research sample will consist of control group (20 participants) and experimental group (30 participants). Non-athletes should not be influenced by other limiting factors such as regular sport training to such an extent. However, even official non-athletes can practise some activity which can influence their level of strength of handgrip muscles. Therefore, special questionnaire will be drawn up whose content will include essential questions connected with their sports background. Participants will answer similar questionnaire (once per week) during 8 weeks measurement as well. Purpose of this particular questionnaire is to provide an additional informational feedback for better understanding of upcoming results. Participants will be instructed of emphasis on truthfulness of filled feedback.

Selection of muscle group

Handgrip muscles will be tested in this research project. Handgrip muscles belong to muscle groups used during daily life situations very frequently even by non-sporting population, therefore these muscles should be more resistant against incidental actions which can cause unwanted strength adaptation. Handgrip muscles will be examined on digital isometric handgrip dynamometer. All participants will be practically instructed in using handgrip dynamometer during first common session before measuring starts. Finally, there will be 3 examinations of handgrip strength measurement (before intervention, after 4 weeks and after intervention – 8 weeks). Measurement requires keeping proper body position – sitting position, whole body relaxed, no shoulder neither elbow movements.

Imagination skills training

First of all, both groups (control/experimental) will be instructed about general information of mental training and mental imagery. Furthermore experimental group will participate in extended mental imagery lesson. Research focuses on intrinsic motor imagery (IMI) attitude. Lesson will include utilization of mental imagery, potential limits of mental imagery and explanation of proper practising. Research intervention will last 8 weeks. Participants from experimental group will practise mental imagery training for 6 minutes twice a day. 6 minutes imagery training consist of 20/20 seconds intervals (20 seconds for imagery/20 seconds for rest). Participants will be also instructed to perform mental imagery training with closed eyes in lying or sitting position. Instructions also include demand on whole body relaxation during practising. All participants will give regular feedback in form of short questionnaire (once per week). Questions focus on description of potential problems connected with motor imagery, feedback about sporting activity, mental tiredness or training time feedback.

Brain activity displaying method selection

Brain activity will be examined by fMRI. This method is able to track activated areas and its changes during time with accurate spatially distinguishing ability. In this research I attempt to use fMRI also as mechanism of testing different rate of activation of particular motor imagery correlating areas. I will observe if the level of activation can change due to motor imagery training process. I will compare this level of activation with effectiveness of mental imagery training. FMRI design includes 3 measurements (Before research intervention, after 4 weeks and at the end of intervention - after 8 weeks). Each fMRI testing unit comprises several 20 seconds interval interventions (mental imagery task). 20 second rest interval follows after each 20 second intervention interval. Participants will perform intervention intervals through listening voice record which will instruct them every 20 seconds.

Clarification and Discussion

Despite all mentioned facts, it seems that designs of mental imagery researches are highly depended on the purpose of study. Therefore, it is necessary to know precisely the intention of the research. Nevertheless, from my experience purpose-related information background is essential too. I suppose that the best results come from this mutual connection. Therefore I attempt to share following potential pros and cons related to methodical crystallization process.

In the first part of research I focused on nature of population. I chose 50 health non-athlete men. I consider 50 participants as an appropriate size of sample. It is preconceived that during IMI is important to concentrate on image precisely without aiming on other disturbing phenomena. As it is mentioned above in the text, I presume that men have better capability to ignore unrelated thoughts and ideas during mental imagery practise than women (Slepička et al., 2009). Therefore I consider IMI as more suitable method for men. On the other hand, it could be interesting to challenge this assumption. For instance, women have better developed peripheral vision than men (Abramov, Gordon, Feldman, & Chavarga, 2012). If research requests to focus on whole or large image (without details) it could be more natural for women to perform it. In this case, I would recommend EMI attitude. Other problematic part could be decision making process between potential athlete or non-athlete participants. Although I consider non-athletes as more appropriate sample, majority of researches does not distinguish between gender of participants and their athlete/non-athlete condition. (Clark et al., 2014; Herbert et al., 1998; Chiew, LaConte, & Graham, 2012; Luft, Skalej, Stefanou, Klose, & Voigt, 1998; E. Naito & Ehrsson, 2001; Eiichi Naito et al., 2002; Ranganathan et al., 2004; Siemionow et al., 2000; Yao et al., 2013). Nevertheless, researches even so bring positive results. This fact supports an idea, that mental imagery ability itself could be the most influencing factor in the process of enhancing strength by mental imagery. On contrary, researches distinguishing between gender and athlete/non-athlete state could reveal some of unknown aspects and limitations of mental imagery. For example, if motor imagery also effects highly adapted muscles which are typical at sportsmen. Obtaining this missing information would be beneficial for further research. If there would be positive results, it could bring new approach into professional sport. In this context, the following question could be asked. Is mental imagery training or its combination with physical performance possible way how to overcome doping crisis?

Further, it must be mentioned that in process of selection of muscle group could be many possible attitudes. Nowadays, there is vast evidence of mental imagery (mind to body) utilization. Some research recommends mental imagery training as an additional method of muscle strength development (Reiser, 2011) or in case of limp immobilization motor imagery practising could also help to keep the level of strength without bigger strength loses (Clark et al., 2014). To sum up, these researches focus rather on supplementary impact of motor imagery. In this research project I prefer to challenge presumption that motor imagery can barely influence muscles which are used on daily base. Hence I focus on handgrip muscles. I emphasise the meaning of handgrip muscles group in daily life situations. This group of muscles are used on daily base on certain level of activity. Therefore, I consider handgrip muscles as an appropriate muscle group. If muscle group is trained on the daily base there is assumption that muscle will be more resistant against other influences such as accidental workload impact. Also, handgrip muscles belong to minor muscle groups, so the concentration on mental image could be easier to hold on. While gaining strength by mental imagery is process of adaptation of neural system (Ranganathan et al., 2004), musculoskeletal adaptation is caused by muscular hypertrophy (Hoffman, 2014). As far as I know, hypertrophic adaptation is relatively broadly described and its limits are essentially explored. Based on known facts, large muscles are stronger than minor muscles. This fact is caused by genetics and its daily use. (Weinberg & Gould, 2011; Tod & Lavallee, 2012; Hoffman, 2014) It follows, that large muscles could be more resistant against motor imagery practise implementation. This provides an opportunity to test effects of motor imagery training on large muscles. Further study focusing on this potential limitation could have valuable outcomes.

From my point of view, one of the most important factors of effectiveness of mental imagery training is time spent in training overall. Accordingly, this research project suggests 20/20 sec. intervals in 6 minute training block twice a day. This proposal is supported by researches which describe the way of adaptation of neural system. Neural system is adapted by increasing of intensity of central command to muscle. (Ranganathan et al., 2004). The data of this research suggest that repetitive mental attempts of maximal muscle activation trained and enabled the brain to generate stronger signals to muscle. Due to this phenomenon it could be claimed that greater strength is a consequence of stronger brain activity. A stronger central command could recruit the motor units that were otherwise inactive in an untrained state and/or drive the active motor units to higher intensity (higher discharge rate), leading to greater muscle force (Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004). As far as I know, only one research project did not report positive results. This discrepancy can be caused due to different imagery training design which is in this case characterised by very short time of practising/performing motor imagery (six times 10 sec. intervals three times per week) (Herbert et al., 1998). There is no specific information about type of motor imagery practise in this research. Whether IMI or EMI was used is not mentioned. On contrary, this study compares changes in level of strength of elbow flexors after physical intervention and imagery intervention. Whereas this study uses same methodical design for both variants, it is interesting that considerable changes after physical exercise intervention appeared. To sum up, it probably means that physical intervention has faster and stronger impact. Nevertheless, comparison of IMI vs. EMI impact on muscle strength was carried out too (Yao, Ranganathan, Allexandre, Siemionow, & Yue, 2013). This study shows, that IMI has stronger impact (10.8% enhancement) than EMI (4.8% enhancement). These results were measured on elbow flexor muscles, which is the same muscle group measured in previously mentioned study. These results have been my inspiration for choice IMI training attitude.

Differences in level of quality of mental imagery ability seem to be very interesting too. Only few researches studied relationship between level of quality of mental imagery and related rate of strength gains (Chiew et al., 2012; Reiser, 2011). Results of these studies were positive. It turned out that motor imagery practitioners with superior mental imagery ability reached better results. In fact, there is also evidence that at least athletes on recreational level could reach same results by only mental imagery practise compared to physical exercise (Reiser, 2011). This phenomenon led me to related questions. Is stronger positive result really related to superior mental imagery ability? Can average mental imagery practitioner reach this superior level by mental imagery training? I presume that during training period (8 weeks) different level of strength enhancement can be recordable. Therefore, I attempt to reveal possible differences between talented mental imagery practitioners and those who belong to rather average level. Hence, this study uses 3 fMRI consecutive measurements. This study requires brain activity displaying method with relatively accurate spatially distinguishing ability and still precise “changes over time” ability. Therefore, fMRI seems to be suitable tool in this field of study. On the other hand, both of fMRI abilities are slightly above average level. Nevertheless, EEG method records changes in time most accurately. Therefore, this method would be more appropriate for studies focusing on “changes in time” measurement but simultaneously with low interests in spatially distinguishing measurements (“Funkční magnetická rezonance / fMRI Brno”, 2004).

Conclusion

This study provides a potential solution in the process of methodical crystallization in study related to use of intrinsic motoric imagination as a method of increasing level of isometric muscular strength contraction of handgrip muscles. I suggest as a suitable sample 50 non-athlete men. Further, I consider handgrip muscles as an appropriate example of muscles which are relatively resistant against incidental actions. This study recommends IMI training attitude as well as frequent practicing of mental imagery (twice a day/6 minutes). Finally, fMRI is considered as the most adequate brain activity displaying method. This study confirms that the most significant factor in methodical crystallization process is knowledge of purpose of study. Although, I consider knowledge of purpose-related information background essential too.

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EVALUATION OF ANAEROBIC THRESHOLD IN ELITE HANDBALL PLAYERS ON DIFFERENT PLAYING POSITIONS USING RATING OF PERCEIVED EXERTION

Uzelac-Šćiran Tomislav, Vučetić Vlatko
Faculty of Kinesiology, University of Zagreb, Croatia

Abstract

Team handball (TH) is a physically demanding sport in which anaerobic threshold (AT) plays a significant role. Although the AT estimation tests are mainly performed in laboratory conditions, assessment of AT in TH is possible in the field, too, using only rating of perceived exertion (RPE). The aim of this paper is to determine possible differences in the determination of AT underpinned by the V-slope method and AT estimated with RPE at the treadmill progressive test in handball players (HP) on different playing positions. The sample included 17 elite HP, members of the Croatian Senior Handball Team. A sample of 12 variables was obtained using a treadmill spiroergometric test, and on the basis of RPE assessment by the respondents during the test. The absence of a statistically significant difference (P=0.59) in the variables running speed at the ventilation threshold (km/h) and running speed at RPE7 (km/h) between the HP, confirmed the hypothesis of this work-HP on different playing positions estimate their AT based on their RPE equally well.

***Key words**: handball, top players, functional test, endurance, playing positions, analysis*

Introduction

TH, combining aspects of basketball, soccer and baseball, is a physically demanding sport; nonetheless, it is one of the most popular sports in the world (Gorostiaga et al., 2006; Sporiš et al., 2010). According to Granados et al. (2007), combined with muscle strength and power, high levels of aerobic capacity are vital for successful competition performance in both male and female HP. On the contrary, some studies (Noakes, 2003) disproved the importance of aerobic capacity, especially the concept of VO2max in high-level competitive performance. Additionally, some of TH studies (Rannou et al., 2001) highlighted the importance of anaerobic, contrary to aerobic characteristics in achieving high-level competitive results. It can be highlighted that HG make a large number of explosive movements, therefore the emphasis is on the anaerobic capacity of the HP, i.e., their ability to maintain a maximum-intensity activity over a short period of time (15-60 s) without significant drops in intensity; however the significance of aerobic capacity should not be disregarded.

In every team sport, there are differences in demands on different playing positions. With respect to the differences between playing positions, according to Šibila et al. (2004), there are significant discrepancies in the percentage of the time spent in maximum intensity activities, which is 4 % for wings, 3 % for backcourt players, and 2 % for pivots. During a handball match, the average intensity is around 70 % of VO2max (Thorlund et al., 2008) and ratio between the high- and low-intensity is between 1:3 and 1:5 (Šibila et al., 2004, according to Bon, 2001).

A very important endurance factor in TH is the AT height. Untrained persons exceed AT at 60-80 % of VO2max, and top aerobic athletes at 80-95 % of VO2max. This means that the trained person will endure prolonged and high load without disorders of homeostasis and drop capabilities due to acidification of the body. AT is a subject of great interest to the scientific community, and long-term controversies related to the AT concept are still not resolved. The reason for this is its great practical application.

AT estimation tests are generally progressive, and they can be performed on a treadmill in laboratory setting. This paper will describe the V-slope method for determining AT. V-slope method is based on the slope of the VCO2 in relation to VO2 curve during progressive exercise test. The method is called the V-slope because it uses the slope of the gas interconnection curve (CO2 and O2). This method has significant advantages over other ventilation methods because it does not depend on the regulation of breathing patterns and respiratory chemosensibility of the subject, which can lead to inability or difficulty in determining AT.

Dosage and distribution of the training intensity is one of the most important components for achieving top results in sports. There are several ways of dosing, estimating and controlling the intensity of the load: RPE; heart rate; pace; power and lactate. No method of dosing and intensity control is complete, i.e., no method can explicitly define the intensity of the activity. Therefore, simultaneous use of multiple methods is recommended, which increases reliability of the measurement.

Comprehensive theory of perceived exertion does not exist yet (Garcin, 2006; Watt & Grove, 1993). Numerous studies have been conducted to identify different physiological components involved in physical exertion and to find out how they vary in relation to perceived exertion (Borg & Ottoson, 1986; Borg, 1998). Perceived exertion is a multidimensional construct based on integration of manifold sensory inputs related to numerous physiological, psychological, and experiential factors (Hassmen, 1995; Borg, 1998). Various of scales have been used to estimate perceived exertion. The RPE scale from 6 to 20 is the most commonly used in clinical, ergonomic, pedagogical and sporting applications (Borg, 1998).

Previous investigators have only dealt with the physiological response that can account for the RPE during cycling exercise (Pandolf et al, 1984) or the contribution of differentiated RPE to overall exertion while swimming (Ueda et al., 1993). Only Garcin (1997) studied both physiological and performance variables for RPE and Estimated Time Limit, especially at the intensity corresponding to the AT. Garcin et al., 2006, used 94 regional to national level athletes (47 endurance-trained runners, 11 sprinters, and 36 HP) to show that RPE and Estimated Time Limit at the lactate threshold was mainly mediated by factors relative to the performance expressed in percentage of the maximum aerobic velocity. Secondary factors that contribute significantly as perceptual predictors were related to various classes of factors, except for psychological factors.

The aim of this paper was to analyze possible differences in the determination of AT underpinned by the V-slope method and AT estimated with RPE at the treadmill progressive test in elite HP on different playing positions. Hypothesis states that HP on different playing positions assess the transition of an AT based on their RPE equally well.

Methods

The sample consisted of 17 elite HP, members of the Croatian Senior Handball Team. HP were divided by criterion-playing position (2 goalkeepers, 8 backcourt players, 2 pivots and 5 wingers). The test was conducted at the Diagnostic Center of the Faculty of Kinesiology in Zagreb, within the Olympic Games preparation cycle. Participant assent were obtained in advance of the study, and ethical approval for the research was granted by the University Research Ethics Committee in accordance with the Declaration of Helsinki.

Table 1. The physical characteristics of respondents

	Valid N	**A (years)**	**BH (cm)**	**BM (kg)**	**BMI (kg/m^2)**
G	2	25,9 ± 1,2	196,7 ± 3,8	100,3 ± 18,5	25,7 ± 3,7
B	8	27,7 ± 2,3	197,6 # ± 6,3	100,8* ± 7,8	25,8 ± 1,5
P	2	29,1 ± 3,7	200,6° ± 3,0	112,9® ± 1,8	28,0 ± 1,3
W	5	26,5 ± 2,9	184,7 # ° ± 9,0	86,1* ® ± 3,8	25,3 ± 1,8
M ± SD		27,3 ± 2,5	194,0 ± 8,9	97,8 ± 11,3	25,9 ± 1,9

Legend: G-goalkeepers; B-backcourt players; P-pivots, W-wingers; M-mean; SD-standard deviation; A-age; BH-body height; BM-body mass; BMI-body mass index

Notice: *-statistically significant difference between B and W (P<0,05); #-statistically significant difference between B and W (P<0,05); °-statistically significant difference between P and W (P<0,05); ®-statistically significant difference between P and W (P<0,05).

A sample of variables was obtained using a spiroergometric test on a treadmill and on the basis of RPE assessment by the respondents during the test: Maximum absolute oxygen uptake-VO2max (lO2/min); Maximum relative oxygen uptake-RVO2max (mlO2/kg/min); Maximum running speed-vmax (km/h); Running speed at the ventilation threshold-vVT (km/h); Running speed at the RPE 7-vRPE7 (km/h); Maximum heart rate-HRmax (o/min); Heart rate at ventilation threshold-HRVT (o/min); Heart rate at RPE 7-HRRPE7 (o/min); Maximum relative oxygen uptake at ventilation threshold-RVO2VT (mlO2/kg/min); Maximum absolute oxygen uptake at ventilation threshold-VO2VT (lO2/min); Percentage of VO2max at ventilation anaerobic threshold-%/VO2max (%), Percentage of HRmax at ventilation anaerobic threshold-%/HRmax (%).

All parameters were obtained based on the treadmill spiroergometric test and the standard protocol (KF05) for the functional abilities evaluated at the Faculty of Kinesiology, University of Zagreb. A progressive treadmill test was carried out. The test records a 1 km/h increment of every minute with a steady inclination of 1.5 %. The breath by breath, spiroergometer, mobile wrist and telemetry heart rate monitor provide on-line monitoring and subsequent analysis of ventilation and metabolic parameters. Constant microclimate conditions in the laboratory increase high reliability of measurement data. Before the measurement, respondents were adequately prepared and dressed. They were familiar with the purpose and protocol of the test. Before the test, the measurer explained the protocol, security and the communication mode during the test. Measurer put the heart rate monitor rubber band on the respondent chest, and he placed a respiratory mask on his face. The mask was connected to the analyzer thorugh the tube. During the test, the respondent did not talk because he had a mask on, only the fingers of his hands showed the signs of the RPE to the measurer.

The actual effort is closely related to the athletic psychological intensity experience and can be quantified by using the Borg scale with values from 6 to 20. For the initial and final value of the scale, values 6 and 20 are taken from the analogy with the HR at rest (60) and HR at maximum effort (200). Diagnostic center on our Faculty uses a modified Borg Scale (0-13, where 0 is very light effort and 13 is extremely difficult effort).

During the first minute on a treadmill respondent is relaxed, then he starts to walk at a speed of 3 km/h and a constant incline of 1.5 %. This speed is constant for 2 minutes and after a total of 3 minutes, the treadmill begins to continuously accelerate by 1 km/h every minute. Test runs to the maximum, i.e., until the subject is no longer able to track the speed of the treadmill. It is important to note that the test can be interrupted every half of full minute when the respondent decides to stop because he cannot keep up with the treadmill speed. During testing, before the end of each load level, asked by the measurer, respondent uses his fingers to show the RPE value in concordance with the modified Borg scale.

After the measurements were performed, the data were analyzed by the program Statistics for Windows 13.2, and standard descriptive parameters were calculated: arithmetic mean, standard deviation, skewness, kurtosis, minimum and maximum value. A univariate variance of analysis was used to analyze differences in functional and anthropometric characteristics, while the Fisher post-hoc test was used to further determine differences in playing positions.

Results

Analyzing the results of Table 1., which shows the basic anthropometric characteristics of HP by playing positions, a statistically significant difference ($P<0{,}05$) between the backcourt players and the wings in the parameter body height was observed; the same goes for the difference between pivots and wings in body height; between backcourt players and wings in the body mass and in the same parameter between the pivots and wings.

Table 2. Basic descriptive parameters for the selected sample of variables obtained by treadmill spiroergometric test with marked variables that statistically differ according to the playing positions

TEST	GOALKEEPERS		BACKCOURT PLAYERS		PIVOTS		WINGERS	
	M ± SD	MIN ± MAX	M ± SD	MIN ± MAX	M ± SD	MIN ± MAX	M ± SD	MIN ± MAX
VO^{2max} (lO^2/min)	5,1 ± 0,0	5,1 ± 5,1	5,6 ± 0,3	5,2 ± 6,4	5,7 ± 0,2	5,5 ± 5,9	4,9 ± 0,8	3,9 ± 5,9
RVO^{2max} (mlO^2/kg/min)	51,9 ± 9,1	45,4 ± 58,3	54,7 ± 4,5	49,1 ± 61,6	50,8 ± 1,4	49,8 ± 51,8	56,7 ± 7,3	48,7 ± 66,6
v^{max} (km/h)	15,5 ± 2,8	13,5 ± 17,5	17,0 ± 1,0	16,0 ± 18,5	16,3 ± 0,4	16,0 ± 16,5	17,3 ± 0,6	16,5 ± 18,0
v^{VT} (km/h)	11,5 ± 2,1	10,0 ± 13,0	12,7 ± 0,9	11,7 ± 14,5	12,3 ± 0,4	12,0 ± 12,5	12,8 ± 1,0	11,5 ± 14,0
V^{RPE7} (km/h)	11,5 ± 2,1	10,0 ± 13,0	12,8 ± 0,8	11,8 ± 14,0	12,9 ± 1,6	11,8 ± 14,0	13,0 ± 0,6	12,0 ± 13,5
HR^{max} (o/min)	190,5 ± 23,3	174,0 ± 207,0	191,0 ± 5,9	184,0 ± 200,0	187,5 ± 7,8	182,0 ± 193,0	192,4 ± 6,3	182,0 ± 197,0
HR^{VT} (o/min)	176,5 ± 20,5	162,0 ± 191,0	169,9 ± 5,8	160,0 ± 175,0	165,0 ± 12,7	156,0 ± 174,0	169,8 ± 6,8	159,0 ± 176,0
HR^{RPE7} (o/min)	177,0 ± 21,2	162,0 ± 192,0	169,0 ± 6,6	162,0 ± 176,0	170,0 ± 2,8	168,0 ± 172,0	170,8 ± 6,7	159,0 ± 175,0
RVO^{2VT} (mlO^2/kg/min)	47,7 ± 3,2	45,4 ± 50,0	46,1 ± 4,4	39,3 ± 52,7	44,1 ± 0,2	44,0 ± 44,2	47,7 ± 5,3	42,4 ± 54,4
VO^{2VT} (lO^2/min)	4,4 ± 0,0	4,4 ± 4,4	$4{,}6^{*}$ ± 0,2	4,3 ± 4,9	$5{,}0^{\#}$ ± 0,1	4,9 ± 5,0	$4{,}1^{*\#}$ ± 0,6	3,4 ± 4,8
% / VO^{2max} (%)	85,5 ± 0,7	85,0 ± 86,0	84,4 ± 3,8	78,0 ± 89,0	86,5 ± 2,1	85,0 ± 88,0	84,4 ± 4,0	79,0 ± 89,0
% / HR^{max} (%)	92,5 ± 0,7	92,0 ± 93,0	89,6 ± 2,5	86,0 ± 93,0	88,0 ± 2,8	86,0 ± 90,0	88,2 ± 1,1	87,0 ± 90,0

Legend: M-mean; SD-standard deviation; MIN-minimum score; MAX-maximum score; VO2max (lO2/min)-maximum absolute oxygen uptake, RVO2max (mlO2/kg/min)-maximum relative oxygen uptake; vmax (km/h)-maximum running speed; vVT (km/h)-running speed at the ventilation threshold; vRPE7 (km/h)-running speed at the RPE 7; HRmax (o/min)-maximum heart rate; HRVT (o/min)-heart rate at ventilation threshold; HRRPE7 (o/min)-heart rate at RPE 7; RVO2VT -maximum relative oxygen uptake at ventilation threshold; VO2VT (lO2/min)-maximum absolute oxygen uptake at ventilation threshold; %/VO2max (%)-percentage of VO2max at ventilation anaerobic threshold; %/HRmax (%)-percentage of HRmax at ventilation anaerobic threshold

Notice: *-statistically significant difference between B and W (P<0,05); # -statistically significant difference between P and W (P<0,05).

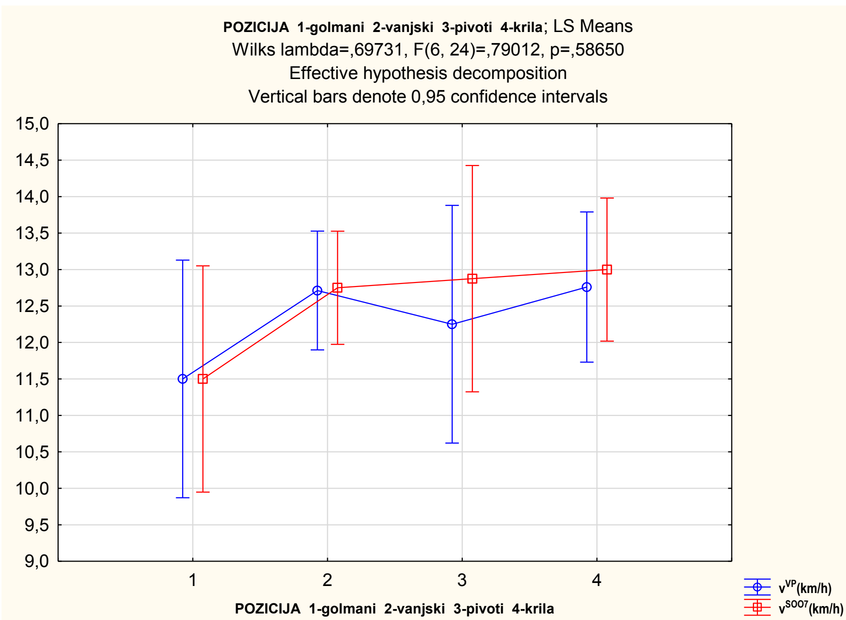

Figure 1. Running speed ratio in variables running speed at the ventilation threshold (km/h) and running speed at RPE7 (km/h) between the HP according to their playing positions

Legend: POZICIJA-playing position; 1-goalkeepers; 2-backcourt players; 3-pivots; 4-wingers, vVP (km/h)-running speed at the ventilation threshold; vSOO7 (km/h)-running speed at the RPE 7

Discussion

Results that were obtained in the Table 1. were not surprising given the fact that in the HG each playing position is characterized by specific anthropometric characteristics of selected HP. The same results were obtained by Ghobadi et al. (2013); Chaouachi et al. (2009); Povoas et al. (2012).

Table 2. contains basic descriptive parameters with marked variables that statistically differ according to the playing positions. Mean values of RVO2max taken from wing players (56.7±7.3 ml/kg/min), backcourt players (54.7±4.5 ml/kg/min) and pivots (50.8±1.4 ml/kg/min) were somewhat higher than the values measured in the papers of Chaouachi et al. (2009) and Sporiš et al. (2010).

Higher values of RVO2max than measured in this paper, have been reported by Milanovic et al. (2015) on a sample of 70 HP of the 1st Croatian Handball League. Dispersion of the results in the RVO2max variable was greater due to the selection of players, i.e., the sport-specific requirements needed for each playing position.

The mean measured values of VO2max variable according to the playing positions are somewhat higher than those measured in the researches of Chaouachi et al. (2009); Sporiš et al. (2010), and slightly below the results obtained by Milanovic et al. (2015).

The same applies to the average values according to the playing positions of variables vmax and vvp, in which Chaouachi et al. (2009) and Sporiš et al. (2010) showed lower results, and Milanovic et al. (2015) slightly higher results.

A statistically significant difference was found in the variable absolute oxygen supply at the ventilation threshold (VO2VT) between the backcourt players and the wingers, and between the pivots and wingers, which can be attributed to the specificities associated with the requirements of the playing position. By analyzing the variable VO2VT, as well as all the other parameters of functional abilities, we have to consider the fact that the sample in this paper was too small (especially in the goalkeeper position-2 players, and the pivot position-2 players), and that for a good interpretation of the measured variables a greater number of HP of the same qualitative rank is needed.

Analyzing the results from Table 2. and observing Figure 1., we come to the conclusion that the results in vVT and vRPE7 variables are not different. This fact, namely the absence of a statistically significant difference (P=0.58) in the mentioned variables between the playing positions, confirmed the hypothesis of this work-HP of different playing positions estimate their AT based on the their RPE equally well.

Conclusion

High anaerobic capacity is an important element for every HP who wants to be successful in training and competition, especially today-HG accelerated due to change of rules. The most important parameter that needs to be known, especially for each individual, before the start of endurance training programming, is the AT. In the training process, the smallest mistakes can affect the ultimate aim of the training, which means achieving top-sports results. Training mistakes can be minimized by precise determination of the work zone based on the defined AT. The ultimate goal of any HP, regardless of the playing position, is to endure a high level of load without disturbance of homeostasis and loss of ability due to acidification.

The results of this paper have shown that top HP of all playing positions can accurately estimate the transition of their AT based on their RPE.

A top HP must understand the importance of training in the intensive aerobic zone to be able to raise the AT level to its maximum limits, while simultaneously eliminating the possibility of overtraining as a result of excessive load.

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PERCEPTION OF FACIAL ATTRACTIVITY OF NON-CONTACT AND COMBATIVE ATHLETES

Vajda Petr
Masaryk University, Faculty of Sport Studies, Brno, Czech Republic

Abstract

Female partner preferences may change over the time. They are influenced by many factors. The key determinants in sexual strategies and perception of attractiveness include fertility and preferences of either a long-term or a short-term relationship. The main differences are in perceptions of male masculinity and the ability to provide and raise offspring. This paper aims to describe changes in the perception of the attractiveness of photographs of male faces of elite golfers (non-contact sport) and MMA fighters (combative sport). The data was collected through anonymous questionnaires from 400 women over the age of 15. A questionnaire included photos of athletes in random order and 1-10 scale rating (10 for the most attractive ones). In this research, the following factors were observed: age, sexual activity/passivity, use of hormonal contraceptives, duration of actual relationship, and number of children they had. For data analysis, the effect size was calculated by using *Cohen's D* between the average mark of contact and non-contact athletes. The greatest differences in the perception of facial attractiveness among the women in the research sample were caused by age and the number of children. This can be explained by low fertility of older women and by lower needs for more offspring in women with more children. In both cases, strong masculine indicators which are typical for contact athletes are no longer so important to women. On the contrary, it can be assumed that most of Czech women of lower age (15-20 years) do not look for a father of their children and a lifelong partner yet, and non-contact athletes are therefore not so preferred. An active sexual life and the use of hormonal contraception show only a small change in the preferences. In both of these cases in which women are expected to have higher fertility, the perception of combative athletes attractiveness has grown slightly.

Key words: *Mating strategy, masculinity, sexual attractiveness, athletes*

Introduction

Sexual strategies and preferences may change. Different approaches are in short-term and long-term relationships. The main driver of long-term partner strategies is replication of genetic information in form of offspring. A woman can give birth only one time during a year even if she is sexually active with a great number of men. Her minimum investment in birth is a long epoch of pregnancy (9 months) and lot of energy. Conversely, a men can beget in one year a large number of offspring with relatively low investment (only coitus) (Buss, 1998). Therefore, the reproductive capacity of a woman depends to a large extent on a choice of a capable partner. According to Buss (1998), signs for an appropriate partner are the ability to get resources and invest them in women and children, the willingness to be in a long-term relationship, the quality of parenting skills, and the ability to protect woman and her offspring.

Attractiveness in men is affected by access to resources and power in the case of long-term relationships. These are often expressed by men in the form of indicators that are durable and difficult to obtain. As such, they should be well recognizable (in our culture, it is social status, clothing, jewellery and other valuables and possession, education, profession, ambition, intelligence, etc.). Signs suggesting that a men will be willing to share resources with his wife and children in the future are also important (Weiss, 2010).

Good look can play a more important role for short-term sexual strategies. Especially physical indicators of higher levels of testosterone and good immunity (body symmetry, musculature, beard, body height, triangular body shape) are preferred. From behavioural characteristics then bravery, courage, strength, glory, and social visibility. Also, sexual urgency, assertiveness, or mild aggression may be important (Weiss, 2010).Such men are more often chosen as extra partners outside of the women's relationship or marriage (Puts, 2010).Significant masculinity and sexual dimorphism increase the number of short-term partners in men (Rhodes et al., 2005). Many of these indicators are typical for athletes, particularly in contact and combative sports.

Male athletes have long been shown to be more sexually active than non-athletes (Grossbard et al., 2007; Wetherill & Fromme, 2007). This can be associated with their high attractiveness for women (fame, social status, health, good shape, and others). Testosterone plays an important role here. For some sports, high levels of testosterone are necessary, especially in contact and combative sports. Men with higher testosterone have more partners during their lifetime while men with lower levels are rated better in parenting skills (Gray, McHale, & Carré, 2017). Testosterone is also associated with lower satisfaction from the partnership (Edelstein et al., 2014) and generally men with higher levels are less married and more often divorced (Mazur & Booth, 1998). High testosterone is an important factor for combat sports. So, it can be concluded that athletes successful in these sports may be less suitable for long-term relationships but have higher success rates and attractiveness for women looking for short-term relationships than their non-contact sports opposites.

Facial attractivity and symmetry

Body symmetry is an indicator of sexual attractiveness and a good indicator of the genetic quality of an individual. More symmetrical men and women report higher number of sexual partners in their life. Women prefer the smell of symmetric men, and even the number of orgasms in women correlates with the symmetry of their partners. Preferences in the masculinity level of the male face fluctuate in women during the menstrual cycle. Some studies have shown that women prefer feminized faces that are likely to signal better parenting abilities (Weiss, 2010). On the other hand, according to Kramer, (2015), when compared to masculine versus other sports and contact versus non-contact, it turned out that athletes in masculine and contact sports have a more attractive facial width-to-height ratio.

Facial perception seems to be a very powerful instrument of sexual strategies. It is possible to read a great deal of information about the individual from a human face. It was demonstrated in the UFC fighters' study that it is possible to identify a more likely winner from the pair of fighter's photos. Women also saw the winners as stronger and more masculine (Little et al., 2015). Similar studies have been conducted several times with equal results. A suchlike ability to perceive male faces has also emerged in endurance sports. There was a connection between the perceived attractiveness of the cyclist and the quality of the performance in the competition on the facial photos of the Tour De France 2012 competitors. This association was less pronounced in women using hormonal contraceptives (Postma, 2014).

Methods

The research sample was obtained from the social network Facebook. Czech groups have been found, by searching for words "women" and "moms".

Selection was dependant on the number of group members. Group managers of the largest ones were asked to place a questionnaire with instructions in their groups. The questionnaire was placed in one group for each term. The first 400 women (age = 29.16; SD = 8.43) who completed the questionnaire were included in the present study. Two men were excluded from the sample due to control question. The on-line questionnaire was fully anonymous and contained 15 photos of golfers (world top players in April 2017) and 15 photos of UFC fighters (world top in ranking -84 kg category). Fighters category was selected according to the average weight of the golfers. The photos had been taken from the official events sites and included only a face on a white background. Those were shown in random order. The women in the study rated the attractiveness of men in photographs on a scale of 1-10, where 10 is the highest mark, i.e. meaning the most attractive. The questionnaire was supplemented with a gender verification and questions about the factors examined: age, sexual activity/passivity, use of hormonal contraceptives, duration of actual relationship, and number of children. The effect size was calculated for the analysis by *Cohen's D*.

Table 1.

	N	All	SD	Golf	SD	MMA	SD	Cohen's D (Golf/MMA)
Whole sample	400	3.27	2.21	3.47	2.22	3.08	2.19	0.18
Sexually active	343	3.24	2.18	3.43	2.18	3.06	2.17	0.17
Sexually non-active	57	3.50	2.41	3.79	2.43	3.22	2.35	0.24
On contraceptives	114	3.27	2.29	3.53	2.31	3.00	2.25	0.23
Not on contraceptives	286	3.28	2.18	3.45	2.18	3.10	2.17	0.16
Age (years)								
15-20	48	2.88	2.07	2.81	2.02	2.94	2.12	-0.06
21-30	219	3.21	2.13	3.36	2.10	3.06	2.14	0.14
31-40	91	3.27	2.31	3.55	2.30	2.98	2.28	0.25
41-50	29	4.07	2.33	4.51	2.24	3.63	2.33	0.38
51-60	42	4.02	2.65	4.86	2.70	3.17	2.31	0.67
No. of children								
No children	195	3.23	2.13	3.34	2.09	3.13	2.18	0.10
1	95	3.38	2.24	3.65	2.27	3.10	2.16	0.25
2	80	3.32	2.24	3.59	2.22	3.05	2.23	0.24
3+	30	3.10	2.55	3.46	2.73	2.74	2.30	0.28
Relationship Length (years)								
5<	154	3.25	2.26	3.52	2.30	2.97	2.19	0.25
2 - 5	91	3.19	2.12	3.28	2.07	3.09	2.18	0.09
0,5 - 2	54	3.55	2.27	3.72	2.25	3.39	2.29	0.14
> 0,5	26	2.97	2.08	3.00	2.04	2.94	2.12	0.03
Singles	75	3.34	2.20	3.59	2.21	3.09	2.16	0.23

Results

The results of comparison of combative and non-contact sport showed, without categorizing the women who rate them, that representatives of non-contact sport are judged by higher marks, but only with a small effect size of 0.18. The most important determinant of preference for male faces seems to be the age. While women under the age of 20 rate contact and non-contact athletes very similarly; women over the age of 51 rate non-contact athletes (mean = 4.86; SD = 2.70) with significantly higher marks than contact ones (mean = 3.17; SD = 2.31). Two trends turned out in the data considering the age factor. The total mark of all athletes and the gap between combative and non-contact is growing with the age of women. The number of children appeared to be a relatively strong factor influencing the perception of attractiveness. Women with a higher number of children favored rather non-contact athletes. Those who have 3 or more children even scored wrestlers with the lowest mark, average only 2.74 (SD = 2.30). This phenomenon can be probably explained by the fact that a large part of these women are no longer willing to have more children, so the masculine faces of the combative athletes are not attractive to them compared to their opposites. Interesting results have been given by data analysis according to the length of the current relationship, where the most significant difference is for women who have a long-term relationship for more than 5 years. This difference can also be due to the higher average age of this group (mean = 32.93; SD = 7.96). Rating was also significantly higher in the single women group of women for non-contact athletes despite the statistically lower age of women (M=27,19; SD = 9,24). It could be assumed that they seek a serious relationship which they do not have, and therefore naturally masculine athletes are less convenient in this respect. More detailed data would be needed. Especially the number of women interested in a short-term and long-term relationship. Predicted result turned out for the factors of sexual activity/passivity and the use of contraceptives. Women who are sexually active and fertile (do not use hormonal contraceptives) do not make such a difference in favor of non-contact athletes. However, this trend is of a little effect size.

Discussion

The data that was collected in the research provide only a small scatter of wide possibilities of factors that affect perceived attractiveness of male faces. To increase the willingness to fill in the questionnaire, only a small number of questions is included due to the effortless. For the next research, it is appropriate to add questions for phase of the menstrual cycle that influences women's preferences (Weiss, 2010) and it may also be important to find out whether a woman is looking for a rather long-term, short-term relationship or an extra partner in the current relationship. The results show relatively low marks for the men evaluated in this study, although they are elite athletes and very socially successful people. However, women rate men by low marks in this research, but this does not work viceversa. This phenomenon can be seen in other studies, too. E.g. (Gladue & Delaney, 1990). Mostly non-contact athletes were preferred to the combative ones. High masculinity may be perceived by women as an indicator of aggression, so masculine faces can be regarded as less attractive (Puts et al., 2012). The biggest difference in preferences for athletes is clearly in women where they are expected to have low fertility and willingness to have additional children (high age or currently high number of children). These women show a decreased interest in significantly masculine men from the MMA environment and judge higher marks for non-contact athletes. High masculinity and testosterone levels are associated with lower paternal capabilities so it is natural that these women groups tend to looking for milder men. On the other hand, women with high fertility and low number of children more perceive the strong genes of masculine men. A group of women under the age of 20 was the only group which preferred combative athletes. It is likely for these women to be less interested in finding potential fathers and life-long partners in the environment of the Czech socio-culture. Also, high fertility can be assumed for them. Hormonal contraceptives that have been widely discussed in recent years have shown only small variations in the perception of male attractiveness.

Conclusion

The female perception of the male facial attractiveness is not the same over the time. Priority vary depending on many factors. Usually woman seek for the greatest benefit. While for short-term relationships without the need to spawn children or find a life partner, current aspects such as physical attractiveness, current spending on women, or social glory could be chosen (Weiss, 2010). From the long-term relationship point of view, women tend to seek men with a high willingness to invest their means, the quantity of resources, and good paternal skills. It seems evident that both strategies could be combined (for example, an extra partner outside the current relationship or marriage). It can be concluded from the existing results in this research area, that women are able to estimate men, their psychological and physical capacities, even their success just from facial images. It is possible to follow changes in female preferences depending on some factors for the combative athletes as representatives of highly masculine activities and non-contact athletes, despite the high success rate of both groups, social status and the means obtained during their lifetime. It is possible to include new parameters in this research design and try to find new connections in the future.

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DOES A RELATIVE AGE EFFECT FORCE DROPOUT OF YOUTH SPORTS? A STUDY OF SIX PRIMARY SCHOOLS IN OLOMOUC, CZECH REPUBLIC

Válek Štěpán
Faculty of Sport studies, Masaryk University, Brno, Czech Republic

Abstract

Dropout of sports, and/or any kind of discontinuation of regular organized physical activities (OPA) in school children mark the onset of potential future difficulties directly or indirectly linked to the lack of physical activities. Early-leaving OPA in our country in this age segment has not been documented enough yet. This paper aims to give evidence on the relative age effect (RAE), presuming that an athlete born in the last quarters of the respective year has lower chances to engage, and/or keep to a given OPA over the time.

RAE appears to be one of the gravest co-factors which affected sport careers of 421 girls, former participants of basketball preparatory schools aged 6-10 at six basic schools in Olomouc, Czech Republic. The data was obtained ex post facto via interviews with their parents, and additionally with the girls after 4-10 years they left their prep schools. Of the total 299 elicited answers almost 70 % went on in basketball or OPA (37.12, resp. 32.10 %) right after the end of their prep-school period. The following dropout in the coming 3-6 years reached 79.28 %, resp. 54.17 %. No significant RAE was found out for the participants´ birth dates distribution ranging from 16.67 % for OPA in the quarters (Q)1+2, 4.5 % for basketball in Q3+4, and 17.40 % for the immediate dropouts in Q3+4. However, other strong motives for discontinuation and detrimental clusters negatively affecting children´s dropout associated to RAE were found.

Key words: *organized physical activities, dropout, relative age, girls, early school-age*

Introduction

When coaching children´s sports, kids dropped out of them represent a little nightmare to any coach let alone their parents, either side finding investments lost during a recruitment process to get the best available candidates along with energy, time, and know-how spent on the players apart from expectations gone in vain.

The worse part of the children´s sport withdrawal arises from biological, psychological, and social benefits the active sporting brings for their future. A large number of studies and reviews have already documented various aspects of the lack of physical activities, and/or their positive effects contributing to the accomplishment of fundamental objectives in children´s development resulting of regularly performed OPA, and from the coaching side, motor skills learning (Strong et al., 2005; Hallal, Victora, Azevedo, & Wells, 2006; Warburton, 2006).

Many early-school children enter their first sporting activities in relatively large numbers in the period of the primary movement expansion in the Grades 1-3 and then they discontinue sports activities, or withdraw from sports in equally large numbers (Burton, & Martens, 1986; Gould, 1987; Coté, & Hay, 2002; Lemyr, Roberts, & Ommundsen, 2002; Roberts, & Treasure, 2012). Dropout of sports has been in focus since 1980s searching for factors causing increasing attrition rates such as generally known missed liking and a "fun factor" along with that time not thoroughly researched perception of children´s own competencies, a credit attributed to the sport by themselves or by their reference groups, a cost-and-benefit analysis considering what a child gains or loses by doing sports or whether a young athlete has to give up OPA because of reasons going beyond their capacity to solve them. There are studies attempting to compile comprehensive theories (Deci & Ryan, 1985, 2000; Klint & Weiss, 1986; Ryan & Deci, 2000; Quested et al., 2013), while other authors address specific OPA dropout motives trying to find solutions such as Orlick (1974), LeBlanc and Dickson (1997), Jõesaar, Hein and Hagger (2012) or again Quested et al. (2013).

RAE refers to the consequences of relative age difference between those within the same-year age group. Not only in the sporting contexts has it been documented that individuals born in the first quarter(s) gain advantages over those born in the last quarter(s) of the year. These advantages encompass components of physical development, thus greater aptitude to perform better than their younger peers, and components linked to maturation such as enhanced cognitive and social development enabling the older players to perform better than their younger peers (Larouche, Laurencelle, Grondin, & Trudeau, 2010; Philippaerts et al., 2006).

RAE in relation to various other factors has been dealt with by Delorme, Chalabaev and Raspaud (2011) showing its association with dropouts both for boys and girls in French basketball, or examining it in connection to the height of players (Delorme, Chalabaev, & Raspaud, 2009) pointing out at "the hasty conclusion that an asymmetric distribution of dates of birth of professional players would be due to RAE" (p.241). Lemez, Baker, Horton, Wattie and Weir (2014) examined a competition level and dropout rates in Canadian male ice-hockey players from ages of 10 to 15 confirming that their dropout was highest among players born in quartiles three and four. A very good point extended to the similar segment was added by Turnnidge, Hancock and Côté (2012) suggesting that RAE plays significant contextual role in Canadian ice hockey.

The most distinctive difference in RAE comes in selection processes for representative teams (Lewis, Morgan, & Cooper, 2015) and in coaches´ selections through try-out systems (Hancock, Ste-Marie, & Young, 2013). Authors find elite players “chronologically and skeletally older than club players and dropouts,” and that they also “perform better in functional capacities” (Figueiredo, Goncalves, Silva, & Malina, 2009, p.889,) adding the key point that there are fewer athletes born “in the months furthest from the cut-off date for the given competition scheme” (p.966) as mentioned by Salinero, Pérez, Burillo and Lesma (2013), and also proven in younger categories of international basketball as by García, Aguila, Romero, Lastra and Oliveira (2012) stating that RAE fades away with age unless for the positions requiring more physical strength.

This paper attempts to support the evidenced experience of the RAE in sports and other OPA in a study related to the dropout of early school-age girls of OPA, namely basketball, and contribute to the understanding of real sporting conditions and better coaching practices in school-, and/or club-run regular physical activities in this segment of population.

Methods

An ex post facto strategy was used in the process of data acquisition from the participants. In order to obtain data interrogation methods, a telephone survey with the participants´ parents and semi-structured interviews with the participants, were employed after the time delay of 4-10 years. The sample consisted of 421 basic school girls (Table 1) in Grades 1-3 aged 5,5-10,5, attending general movement preparatory schools at 6 basic schools in Olomouc, Czech Republic, from 2006 to 2012. The schools formed a representative sample of the female youth in this regional city. 8 girls labelled “Others” were added to the basic sample. They met the criteria of the age and parallel engagement in OPA not enrolled in the prep schools. The girls were between 11-23 at the time of data collection (January-June 2016).

After data cleansing the cohort was divided into 3 groups for further examination. Those who continued in sports right after the end of their prep school period, were subdivided into Group 1, basketball, and Group 2, other OPA, and the Group 3 were the immediate dropouts.

Table 1. Number of pupils at primary schools and participants of prep schools

PS	∑pupils	∑girls in preps	∑answers	∑% answers
PS1	546	71	51	71.83
PS2	367	96	67	69.79
PS3	475	51	37	72.55
PS4	202	25	18	72
PS5	419	87	57	65.52
PS6	592	83	61	73.5
Others	8	8	8	100
Total	2, 609	421	299	71.02

Note. PS = primary school with a prep school; ∑*pupils* = total number of pupils acc. the School Year Reports; ∑*girls in preps* = total number of girls in prep schools after data cleansing; ∑*answers* = number of acquired answers; ∑*% answers* = rate of acquired answers.

Following the research objectives, the following research questions were formulated:

1. What was the rate of the girls going on in basketball and OPA against the immediate dropouts right after the initial period in a prep school?
2. Was there a prevalence of the participants´ birth dates falling in the Q3 and Q4 of the respective year?
3. Could there be traced other frequently repeated answers going against the participants´ further engagement in the chosen OPA?
4. Were there significant contextual dropout clusters linked to the RAE negatively affecting the participants´ further engagement in OPA?

Results

Of all the elicited answers, see Table 2, 37,12 % of the girls went on directly in basketball or in other OPA (32,10 %) after they ended up their prep schools, whereas 30,77 % quit OPA completely. The total number of sporting girls in that transition period reached 69,22 %.

Table 2. Group distributions after end of prep schools – 1 basketball, 2 other OPA, 3 dropouts

PS	∑As	∑BB	∑OPA	∑DO	% G1/G2/G3
PS1	51	24	12	15	47.05/23.51/29.42
PS2	67	19	21	27	28.36/31.34/40.30
PS3	37	8	10	19	21.62/27.03/51.35
PS4	18	6	6	6	33.33/33.33/33.33
PS5	57	18	23	16	31.58/40.35/28.07
PS6	61	28	24	9	45.90/39.34/14.75
Others	8	8	0	0	100/0/0
Total	299	111	96	92	37.12/32.10/30.77

Note. *∑As* = obtained answers; *∑BB* = continued in basketball; *∑OPA* = continued in other OPA; *∑DO* = immediate dropouts, no OPA; *% G1/G2/G3* = group rates per cent.

Table 3 shows the Group 1 with a slight prevalence of birth dates in the Q3+4 (-4.5 %), Group 2 for 16.67 % older in the Q1+2, and the Group 3 scoring 17.40 % of distribution in Q3+4.

Table 3. Total birth dates distributions of Groups 1 BB, 2 OPA, and 3 DO in year quarters

Groups	∑	Q1+Q2	%	Q3+Q4	%	Q1,2-Q3,4
1 BB	111	53	47.75	58	52.25	-4.5
2 OPA	96	56	58.33	40	41.66	16.67
3 DO	92	38	41.30	54	58.70	-17.40
Total	299	147		152		

Note. *∑Q1+Q2* = January-June; *∑Q3+Q4* = July-December; *∑Q1,2-Q3,4* = percentage difference between the 1st and 2nd half of the year.

Number of dropouts and girls remained active doing OPA after the period of 3-6 years since the start of their OPA as described in Table 4 spoke for Group 2 with more than half of them sticking to some OPA at the age of 14-15 while almost 80 % of girls in Group 1 left not only basketball but withdrew from organized sports at all.

Table 4. Number of dropouts/remained in Groups 1,2 after 3-6 years since start of OPA

Groups	∑	DO	%	stay	%
1 BB	111	88	79.28	23	20.72
2 OPA	96	52	54.17	44	45.83
Total	207	140		67	

Note. ∑*DO* = dropouts within 3-6 years after the start of regular OPA, i.e. aged 14-15; ∑*stay* = number of the remained in OPA after the start of regular OPA, i.e. aged 14-15.

Table 5 gives the list of major variables reported by the girls as those discouraging them from further sporting engagement. Bad coaching bad practices placed the first among all other ones, ranging from the lack of expertise to maltreatment including negligence, favouritism, foul language, shouting at players, and even bullying. Quite a few participants did not feel like attending “top sport” augmented by the selections for the games and competition inside the team. Unsurprisingly some of them “did not want to spoil the game”, and/or “did not feel good enough to play” labelled here as feelings of one´s own incompetence. Health reasons were mentioned on different levels of significance as well as changing teams, very often associated with the shift to older category. Some of the girls felt fulfilled and went for a different, low-sport, and/or a non-sport activity. Breaking up teams turned out to be quite an often reason in this cohort, mainly if parental interference had been at the background of it. Bad in-team relationships with the girls were of a high importance and along with external (moving places, time, travelling) and family matters (divorce, lack of finance) were hard to overcome for adolescents dependent on their parents. School requirements, fatigue and burnout and accelerated “fast-track stars” caught up by the rest of the team in time had lower appearances and represented minor difficulties.

Table 5. Variables negatively affecting participants´ chances to stay in sports, Groups 1+2

coach	high Int	own incomp.	health	team shift	low Int	breakup
43	34	22	19	17	19	16
relation	extern.	sport	family	school	exert.	accel.
16	14	12	10	5	4	4

Note. ∑*coach* = bad coaching practices; ∑*high Int* = high intensity top sport; ∑*own incomp.* = perception of own´s incapacity; ∑*health* = injuries, illnesses; ∑*team shift* = change of a team; ∑*low Int* = efforts to change for a low level (O)PA; ∑*breakup* = end of a team; ∑*relation* = relationship difficulties in a team; ∑*extern* = external setbacks; ∑*sport* = change for another OPA; ∑*family* = internal family problems; ∑*exert.* = exertion, burnout; ∑*accel.* = accelerated individuals.

Discussion

RAE is one of the principal co-factors effecting young athletes´ participation or withdrawal from OPA. However, the surrounding conditions, extrinsic and intrinsic variables, make it happen to the detriment of a young athlete, or stay latently away till an individual can grow up and mature.

Knowledge and understanding RAE has its role in the selective and try-out teams (Lewis et al., 2015; Hancock et al., 2013), a fact that the author of this paper can confirm having been twice a national junior team´s coach along with conditions and pressures around these selections and consequent impacts coming out of these policies. The same facts were proven by Wattie et al. (2012) in German youth sports clubs that the relatively older in the same year´s age group sample had a higher chance to appear in the sports selections. They found no RAE, except for ´artistic´ sport participants suggesting that relative age-related dropout effects may be context sensitive and different for males and females.

I am in the line with these facts. The seemingly excellent 69,22 % of almost 300 girls going on in OPA had little in common with RAE, distribution of birth dates ranging within a standard deviation on either side. It was a random, natural, non-selective process in the period of primary movement expansion enhanced by the particular ball sport and the figure of the expert coach. The quicker and sometimes harsher were then the numbers of dropouts due to the documented change of conditions. That was why no significant prevalence in the participants´ birth dates in either of halves of the respective year was found.

The figure of a coach, namely the first child´s coach opening sports to them plays a crucial role in the children´s decision whether or not to continue in OPA and physical activities at all. The sadder was the documented fact that coaches and their maltreatment ranked the first among negatively affecting variables towards OPA. Unwillingness to practise and compete on the high level resulting in the shift to low-intensity, and/or non-sporting activities came the second. Perceived inner doubts and fears about their own competencies augmented by the change of a team mainly for an older category with uncomfortable atmosphere for the novice, made a good number of girls leave OPA.

A typical contextual dropout clusters significantly affecting the participants´ further engagement in OPA were found. Unfortunately, there was almost a typical crossover situation of an incompetent, abusive coach working with a relatively younger girl who was sent to an older category where she met hostility from her older teammates having less playing time, doubting about her competencies, losing confidence and leaving the team. If other "hard" conditions beyond the girl´s capacity to solve turned out, the child was simply forced to quit.

Conclusion

This study has shown that the immediate rate of incoming early-school-age girls in basketball or OPA right after the period of a prep school was very high against the immediate dropouts. The second major finding was that there was no significant prevalence of the participants´ birth dates distribution in either half of the respective year. The results of this study indicate that there are frequently repeated variables hindering the participants´ further engagement in the chosen OPA, see Table 5. The role of the coach and, above all, the first coach is crucial. Merged into their relative age, inadequately perceived own competencies, an excessively experienced intensive practice, and the shift to older category they form a deadly cluster for a young athlete resulting in a dropout of OPA. Taken together, these findings suggest that a deeper quantitative and qualitative insight into children´s sport dropout should continue as understanding the sum of 421 items cannot substitute the understanding of 421 case studies.

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DIFFERENCES IN TESTING THE ASSESSMENT OF MAXIMUM OXYGEN OF YOUNG VOLLEYBALL AND HANDBALL PLAYERS

Zekić Robert[1], *Vučetić Vlatko*[1], *Pejčić Tena*[2]
[1]*Faculty of Kinesiology of the University of Zagreb*
[2]*Faculty of Teacher Education of the University of Rijeka*

Abstract

Purpose: The main objective of the study is to compare the estimated maximum oxygen uptake results based on the BEEP test in handball and volleyball players aged 15-17, the SPRINT 20m speed explosion test results, and to establish the correlation between maximum oxygen uptake at performance and results at 5, 10 and 20 meters of sprint. *Methods*: The sample of examinees in this study was divided into two groups according to the sport, namely 13 volleyball players and 13 handball players aged 15-17. Aerobic energy capacity has been evaluated for examinees by a BEEP test, whereby the parameters of maximum reach in the test (RBEEP) and the total exceeded distance (RBEEP-m) has been measured the estimated algorithm value VO_{2max}. The explosive power of the speed has been measured by a 20 meter sprint test with a passing measurement at 5 and 10 m (MES5m, MES10m and MES20m). To compare two groups of examinees, ANOVA has been used to compare the individual difference in the tests performed. The results correlation between the variables has been calculated by the Pearson correlation coefficient. *Results*: It can be confirmed that the differences between handball and volleyball players are statistically significant in sprint results of 10m and 20m. In the FTBEEP aerobic endurance test, there has been no statistically significant differences between these two groups although this ratio may be expected to change in favor of handball players as they have been younger in the research and it is to be expected that specific training operators shall also have a positive effect. *Conclusions*: The data processed in this study do not confirm the differences in energy capacity and the correlation between FTBEEP and MES5m, MES10m and MES20m. Estimated VO_{2max} is not related to results at 10m and 20m although there should be a connection between BEEP test and running speed (although we do not expect high correlation values) because it is anticipated that athletes who are quick and have a greater ability to accelerate the body to show that speed multiple times and maximally, they tend to be less tired during the acceleration of the body, to delay fatigue and thus endure longer in the test and achieve significantly higher running speeds.

Key words: *maximum oxygen uptake, physical fitness, athletic performance, Léger test*

Introduction

A simple movement or complex movement structure is the result of muscular activity that use energy from two different energy systems, aerobic or anaerobic, depending on the sport. In cyclic sports, in which endurance usually dominates, the basis for energy generation is primary the aerobic capacity defined as the maximum amount of oxygen that the body can spend in one minute at intense physical activity (VO_{2max}), which is accepted as the best measure of athletes' aerobic abilities (Vučetić and Šentija 2005). Short term sports and sports of high intensity activities use most of the energy from anaerobic energy capacities while many team sports of relatively long duration and varying pace and activity intensity provide energy for activity from aerobic and anaerobic sources. To develop energy capacities, aerobic endurance is the primary functional capability defined as cardiovascular endurance that manifests by performing high intensity activity for a longer period and delaying fatigue.

Volleyball is part of a group of highly intense intermittent sports games dominated by multiple short periods of explosive movements (dominated by anaerobic energy capacity and renewal of ATP primarily takes place with the help of phosphate (P) and creatine phosphate (CP)), separated by periods of short breaks, during which the athlete is recovering to a smaller or greater extent (for which the most important is aerobic energy capacity) (Sheppard et al., 2009). Handball is dominated by the precision, the speed of repeated sprints (dominated by anaerobic glycolytic energy capacity) and the explosive power of the jump type that needs to be made at the highest level (with dominance of anaerobic energy capacity dominated by phosphate (P) and creatine phosphate (CP) capacity) in order to achieve the best results in certain situational conditions (Buchheit et al., 2010, Saeterbakken et al., 2011) with occasional less intense activities such as standing, walking or jogging (re-domination of aerobic energy capacity) (Michalsik et al. 2013a), which proves the need to develop both components of energy capacity in handball. Considering the situation requirements in both sports, it is necessary to quickly generate energy for the performance of particular movement structure and in periods of lower intensity or rest periods during the match, to regenerate quickly for which the basic aerobic energy system is responsible (Van Heest, 2003). Aerobic capacity diagnosis can be performed in laboratory (precision of controlled load) or by field conditions, by indirect method (algorithms and calculations), but the result is always the effect of cardiovascular, respiratory and muscular system expressed through VO_{2max} (Vučetić and Šentija 2005). Field progressive tests are specific by the intensity of the load determined by predefined sound signals at a precise interval and are evaluated by the distance the subject had passed in the given time or number of run levels and intervals (Vučetić, 2009). The intent of this study is to compare the estimated maximum oxygen uptake results based on the BEEP test in handball and volleyball players aged 15-17 years, the SPRINT 20 m speed explosion test results, and to establish the correlation between maximum oxygen uptake at performance and results at 5, 10 and 20 meters of sprint.

Methods

Sample of examinees

The sample of examinees in this study has been divided into two groups according to the affiliation of the sport, namely 13 volleyball players and 13 handball players aged 15-17. They are all active athletes and are included in the sports program for at least 5 years. They actively participate in the first stage of national sports competitions within their age category and at the time of the test they have all been healthy and without signs of injury and have trained 5 training sessions a week x 1.5 hours. Each athlete has been acquainted with the tests that have been conducted during the competition season.

Sample of variables

To assess morphological characteristics, body height – ALVT and body weight – AVTT have been measured according to the recommendations of the International Biological Program (IBP, Mišigoj et al., 1995).

Examinees have been measured by a standard beep test (BEEP test - Leger et al., 1982), whereby RBEEP (parameters of maximum reach in the test) and total RBEEP-m (total exceeded distance) have been measured. Based on the run distance in the test, VO_{2max} values have been estimated using the algorithm (Leger et al., 1988). In addition to the assessment of the aerobic capacity test, the explosive power of the speed type with the sprint test at 20 meters has been measured with the passing measurement at 5 and 10 m (MES5m, MES10m and MES20m).

Measurement protocol

Before testing the players have been informed with the test protocol and started the warm-up process that included 15-minute running at 70-80% of the maximum heart rate, then 4-6 accelerations of increased intensity of 20 to 40 m. After warm-up they started implementing progressive BEEP test whereby examinees must have run between two marks, while running speed has been determined by the sound signals recorded on the CD. The test has been considered completed at the moment when the examinees could not have maintained the default running speed. The test scores have been entered as level and run distance, i.e. running speed. The purpose of the test is to estimate aerobic energy capacity by estimating maximum oxygen uptake (VO_{2max}) by incorporating the obtained results into the algorithm according to Leger et al., 1988. The next day a Test SPRINT 20 meters has been carried out with a passing measurement at 5m and 10 m. It has been performed 3 times and used to estimate the explosive power of the speed type and its components (response rate to sound stimulation and start acceleration speed) and the best achieved result has been entered as the time needed for overcoming the 20 meters section and passing through 5 and 10 meters.

Statistical data processing

The data obtained have been analyzed by the packet Statistics 12.0. Basic descriptive statistical parameters have been calculated for the groups of examinees. To compare two groups of examinees, Analysis of variance has been used to compare the individual difference in the tests performed. The results correlation between the variables has been calculated by the Pearson correlation coefficient. The level of statistical significance has been set at error $p < 0.05$.

Results and Discussion

Table 1. Basic descriptive indicators of the tested groups

variables	handball players (n=13)	volleyball players (n=13)
AGE (yrs.)	15,59 ± 0,26	16,24 +/- 0,76
ALVT (cm)	171,21 ± 5,69	176,06 +/- 9,34
AVTT (kg)	65,15 ± 7,08	65,42 +/- 7,75
FTBEEP (level)	9,46 ± 2,11	8,05 +/- 1,77
MES5m (sec)	1,60 ± 0,06	1,66 +/- 0,11
MES10m (sec)	2,43 ± 0,08	2,54 +/- 0,09
MES20m (sec)	3,87 ± 0,10	4,08 +/- 0,13
VO2max (lO2/min)	45,06 ± 7,34	40,29 ± 6,26

* the results are shown as arithmetic mean +/- standard deviation

In the previous studies, the highest mean height of 179.0 ± 0.0 cm has been determined for seven national handball team players of Norway and a body weight of 72.0 ± 6.3 kg (Ronglan et al., 2006). Anthropometric characteristics such as body size, body mass, BMI, and the percentage of subcutaneous fat tissue play a very important role when talking about sports success and results (Čizmek et al., 2010). For the volleyball players, Gabbett et al. 2007 determined the average height and weight of 177 +/- 6 cm and 66.8 +/- 1.2 kg. High-quality selection of tested players can be confirmed if it is known how important the height is for success in the game. For volleyball, which is not a contact sport, large muscle mass is not required for successful performance and can even negatively affect the repetition of leaps (Sheppard et al., 2009). Since volleyball is characterized by frequent leaps and rapid changes in direction, excessive subcutaneous fatty tissue is not recommended, which may be a potential factor for injury to the back and knee (Milić et al., 2013). Players with higher body mass indexes move slower on the field and have worse jumping skills compared to their teammates of lower mass but equal strength and ability (Sheppard et al., 2009). Since it is expected that the impact of growth and development shall have positive effects on test results, Ingerbrigtsen et al., 2013, in the Norwegian survey of the U-18 and U-16 players denied the impact of growth and development, and did not determine more accurately statistically significant differences in performance in speed and vertical rebound tests. From the basic descriptive parameters, it can also be concluded that in the functional FTBEEP and the MES20m motor test at 5m and 10m handballs players achieved better results, which can be attributed to a quality selection and training process focused precisely on the development of aerobic endurance, maximum speed and change direction of movement (Michalsik et al., 2013a). In handball these have significant impact on performance and situational efficiency. It is known that the lines of motion are actually between two lines of seven meters and for running counterattack and fast transition from defense to attack and vice versa starting speed and section up to 20 meters in length are key to modern handball, dominated by an aerobic energy component that is responsible for successful and effective regeneration in parts of the game's lower intensity or breaks. The results of the BEEP test, which have been converted by the algorithm (Leger et al., 1988) and represent estimated VO_{2max} for handball players 44.9 ml/kg-1/min-1 and volleyball players 40.2 ml/kg-1/min-1 are orientation values that for trainers can be the basis for planning and programming of training providers aiming at the development of aerobic abilities, comparing them with the high values VO_{2max} of the Norwegian handball players 55.5 ± 3.9 ml/kg-1/min-1 (Manchado et al. 2008) who have been demonstrated connectivity with players' performance and results at major international competitions. In volleyball Lidor and Ziv 2010, described VO_{2max} values ranged from 41.7 to 49.9 ml/kg-1/min-1, which have been slightly lower than the value of basketball players and handball players, suggesting the lower importance of well-developed aerobic performance. Studies conducted to determine and evaluate VO_{2max} for the volleyball players have been different and ranged from 42 ml/kg/min (Martel et al., 2005), performed on the submaximal load on a bicycle ergometer with girls aged 14-15 years, followed by 37.0 ± 0.8, 39.3 ± 7 and 41.2 ± 9 ml/kg/min (Gabbett et al., 2007), performed with a field test with a progressive load on 15-year-old players, as well as test on treadmill with results of 46.6 ± 2.9 and 56.7 ± 4.17 ml/kg/min (Tsunawake et al., 2003) with players aged 17.5. It is common to all that the results vary depending on age, growth and development and the type of test and protocol because the results obtained by bike treadmill, treadmill or field test have not been compatible and comparable and should be analyzed with caution (Vučetić, Sukreški, Sporiš, 2013). In volleyball, given the dimension of the playground and the type of movement, players have no need to develop a maximum speed at 20 meters, since all movements are performed within 3-5 meters up to 10 meters when a defensive ball is played (Grgantov et al., 2013).

Table 2. Analysis of variance - the difference between handball and volleyball players in the results of the conducted tests

variables	handball players AS+/-SD	volleyball players AS+/-SD	F	p
FTBEEP	9,46+/-2,11	8,05+/-1,77	3,362	0,079
MES5m	1,60+/-00,6	1,66+/-0,11	4,231	0,051
MES10m	2,43+/-0,08	2,54+/-0,09	9,935	0,004*
MES20m	3,87+/-0,10	4,08+/-0,13	23,064	0,000*

** Legend - arithmetic mean AS, standard deviation - SD, F - test, the level of statistical significance is set at error p <0.05*

Analysis of variance has revealed individual differences between the measured tests of the two groups and from Table 2 it can actually be confirmed that the differences between handball and volleyball players have been statistically significant in sprint results at 10m and 20m. The results on the 5m sprint have not confirmed statistically significant differences, although the differences have existed and actually have been in the border area to become significant. Within the first 5 meters of running the start acceleration has actually been dominant, which is an important handball skill in the moments of taking the ball and the fast transformation from the defense phase to the attack, while the volleyball players have had well-developed neuromuscular mechanisms of showing a fast and precise movement with a line of motion between 3-5 meters relating to a game in which the ball is extremely fast and precise and should respond with the same reaction to successfully defend and create preconditions for counterattack organization. In the FTBEEP aerobic endurance test that actually estimates maximum oxygen uptake, handball players have scored an average better score of 44.90 ml/kg-1/min-1 versus volleyball players of 40.2 ml/kg-1/min-1, but there has been no statistically significant differences between these two groups, although it has been expected that this ratio shall change in favor of handball players as they have been younger in the research and it is expected that specific training providers shall have a positive effect. Therefore, differences in VO_{2max} are likely to be due to factors such as genetics, selection and training, not the effects of maturation. One of the questions that has been asked is actually the correlation between the results in the progressive load test (FTBEEP) and the speed of running at 20m (and passes at 5 and 10 m) and whether the athletes of structurally different sports differ in functional and motor skills. It is to be expected with regard to the sport, that the handball players who have achieved better results in the BEEP test achieve better results in the running test at 20m because a larger number of running sections means running at a higher speed but also running a significantly larger number of 20m sections (which implies in each section acceleration and deceleration of the body - which is a typical movement structure in handball and not typical in volleyball). The data processed in this study have not confirmed the correlation between FTBEEP and MES5m, MES10m and MES20m. The results have indicated that the estimated VO_{2max} has not been related to the results at 10 and 20 meters. However, individual analysis of the best prepared handball player achieving the best results in the BEEP test (12.5) and results at 20m (3.86 s) and passes at 5 and 10m (1.59 and 2.40 s) suggests that the relation between the BEEP test and running speeds should exist (though with relatively low correlation values) since the best volleyball player had a poorer score in the BEEP test (11.4) but also in the results at 20 m (4.04 s) and the 5 and 10 m passes (1.68 and 2.51 s). It has been anticipated that athletes who are quick and have a greater ability to accelerate the body to show that speed multiple times and in maximum, to have less fatigue during acceleration of the body, to postpone fatigue and thus to endure longer in the test and to achieve significantly higher running speeds.

Table 3. Correlation - the correlation between the results of different tests between handball and volleyball players in conducted tests

variables	FTBEEP	MES5m	MES10m	MES20m	Vo2max	RBEEP
FTBEEP	1,00000	-0,101738	-0,155873	-0,163218	0,991368*	0,998857*
MES5m	-0,101738	1,00000	0,904957*	0,738252*	-0,076203	-0,111211
MES10m	-0,155873	0,904957*	1,00000	0,907219*	-0,118858	-0,173743
MES20m	-0,163218	0,738252*	0,907219*	1,00000	-0,124831	-0,186403
Vo2max	0,991368*	-0,076203	-0,118858	-0,124831	1,00000	0,990035*
RBEEP m	0,998857*	-0,111211	-0,173743	-0,186403	0,990035*	1,00000

**Legend - FTBEEP - beep test, MES5m - sprint passage at 5 meters, MES10m - sprint passage at 10 meters, MES20m - sprint passage at 20 meters, VO_{2max} - estimated maximum oxygen uptake, RBEEP - total ran meters for the exceeded section, level of statistical significance at error $p < 0.05$*

Conclusion

In order to obtain exact parameters, it is necessary to carry out the diagnostic of basic and specific abilities that highly correlate with the success in sport. Given the choice of a large number of laboratory and field tests, coaches shall decide on those which are generally available, simple to implement and compare, and have high validity and reliability in order to obtain results by measuring which exactly describe the status of training, the abilities or skill they want to measure and based on which they want to plan, program or correct their training processes. As researches in the functional space, maximum oxygen uptake in younger age categories are not sufficiently conducted compared to top athletes of both sports, the data can be useful to coaches for effective comparison of players and setting normative values based on which selection and routing procedures can be performed more efficiently, as well as for detection of performance weakness that can be corrected by the training process. In this study, the results of the BEEP test and the SPRINT test have been compared at 20 m between the handball and the volleyball players with the aim of determining differences within the fitness condition of these two groups of players. It has been concluded that the differences exist although statistically significant only in the SPRINT 20m test at passing 10m and 20m which can be explained that handball players who had better results have been well-selected and focused on sport and that specific fitness training has been given a positive transfer according to the energy structure of sport.

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HOW ONE YEAR OF SYSTEMATIC TRAINING CHANGES THE SHOOTING PERFORMANCE IN A GROUP OF YOUNG BIATHLETES?

Žák Michal[1], Ondráček Jan[1], Hřebíčková Sylva[1], Struhár Ivan[2]
[1]Department of Athletics, Swimming and Outdoor Sports, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic
[2]Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Purpose: Performance of biathletes depends on many factors (for example wind speed, lighting conditions, air temperature, athlete's concentration, shooting accuracy and time and many others). The previous findings of our research proved a relationship between exercise intensity and athlete´s postural stability (centre of pressure area and anterior-posterior movement of the centre of pressure) during shooting at a standing position. Moreover, it is important to mention that not only postural balance plays a role in shooting accuracy. The objective of this paper is to evaluate a one-year progress in shooting skills of young biathletes during a systematic training. The training process of participants was mostly focused on their shooting skills, balance abilities and the development of strength-endurance abilities.

Methods: Twelve healthy, well-trained biathletes (5 girls, 7 boys) volunteered to participate in the study (Girls: age 15.8 ± 0.74 years, body weight 55.20 ± 5.70 kg, body height 1.65 ± 0.03 m, VO_{2max} 54.62 ± 3.29 $ml.kg^{-1}.min^{-1}$, W_{max}/kg 4.8 ± 0.39; Boys: age 15.0 ± 0.75 years, body weight 57.42 ± 6.47 kg, body height 1.71 ± 0.07 m, VO_{2max} 65.3 ± 2.85 $ml.kg^{-1}.min^{-1}$, W_{max}/kg 4.9 ± 0.22). The centre of pressure area and anterior-posterior sway were measured by a foot pressure scan (FootWork Pro). Shooting performance and rifle stability were measured by SCATT Shooter Training System. All of these parameters were measured in rest and after a physical load (skating on roller skis) expressed by the percentage of maximum heart rate (HR_{max}) (5 minutes, 65-75% of HR_{max}; 5 minutes, 75-85% of HR_{max}; 5 minutes, 85-95% of HR_{max}). This paper presents the changes over a period of one year.

Results: The stability of the rifle (the length trajectory of motion of the barrel in the last second before a shot) during the testing in rest and after a physical load was improved for all the participants. The rifle stability in the standing shooting position improved: in rest – boys (24.3%), girls (6.2%); Intensity 1 65-75% of HR_{max} – boys (19.5%), girls (13.9%); Intensity 2 75-85% of HR_{max} –boys (1.8%), girls (13.0%); Intensity 3 85-95% of HR_{max} – boys (16.1%), girls (17.1%). The improvement of anterior-posterior sway was found after the systematic one-year training for all biathletes.

Conclusion: The results of our study showed improvement of young novice biathletes in their shooting skills. It can be assumed that the athletes' progress should continue during the next year if the same training concept is continued. To conclude, these results suggest not only progress of the biathletes but also the importance of evidence for predicting the performance in a future sport career.

Key words: *anterior-posterior movement, biathlon, centre of pressure, heart rate, training*

Introduction

Performance in biathlon depends on both main components of this sport i.e. skiing speed and accuracy of shooting. Each biathlon race includes shooting both in the prone and standing position. Both shooting positions require specific skills and abilities of athletes. The basis of the whole shooting process is to master the shooting skills in the prone position. Subsequently it is necessary to transfer particular elements of shooting skills to the standing shooting position which is much more difficult due to a higher center of the gravity. Shooting is a very complex process which has to be learnt by all athletes for several years.

Biathlon shooting performance in the standing position is influenced by many different factors. Ondráček (2011) divided these factors according to their character into two basic groups: psychosomatic (i.e. endogenous) and technical (i.e. exogenous). It is not only the factors of one group but a combination of factors of the both abovementioned groups which plays a decisive role in shooting result of biathletes. The exogenous factors (such as wind, lighting conditions, outdoor air temperature, etc.) often affect the shooting performance of a biathlete more strongly than the endogenous ones during the training process as well as during the race. However, these exogenous factors have minimal effects on the outcome in research with measurement in laboratory conditions. The important fact for our present study is that the endogenous factors have a primary influence on long-term success in shooting in the standing position; especially we have to point out the level of postural stability, the stability of the rifle and the actual heart rate (HR) during shooting. Heart rate is one of preconditions for shooting success in biathlon. The elite biathletes arrive at the shooting range with the level of the heart rate around 160–180 bpm. Their heart beats around 140–170 bpm during the first shot. They leave the shooting range with the level of the heart rate at around 120–140 bpm. Other authors of papers have spoken about the dependence on inter-individual skills of participating shooters and simultaneously they substantiated the importance of stabilization during movement of the barrel in vertical plane during the aiming phase. These authors regard the postural stability as a limiting factor of shooting in the standing position in biathlon and agree that the physical load belongs to one of the most limiting factors in biathlon (Mononen et al., 2006; Sattlecker et al., 2007; Straňák, 2007; Ondráček, 2011; Vonheim, 2012; Baca & Kornfeind, 2012; Mojžíš & Paugschová, 2013).

The aim of this study is to verify the improvement during one year in shooting success in the standing position by the biathletes who were novices in the junior category. Our assumption was: one year of systematic training will positively change the shooting percentage performance of the young biathletes. Our present study had been preceded by a pilot study which had been carried out in July 2016. At that time, the participants of our research advanced to an older age category that meant a change of shooting from an air rifle during the children's category to a long rifle. In the pilot study we carried out the same measurements as in our present study one year later.

Methods

Experimental approach to the problem

The aim of this study is to investigate the one-year progress in the shooting skills of young the biathletes during a systematic training. We compared the results of the rifle stability measurements expressed by a length trajectory of motion of the barrel in the last second before a shot and the anterior-posterior sway of the centre of the pressure movements during the shooting.

Subjects

Thirteen national junior biathletes signed up voluntarily to participate in the study, from which twelve successfully completed all the measurements.The testing procedures were pre-approved by the Ethics Board of the Faculty of Sports Studies, Masaryk University (Brno, Czech Republic).The exclusion criteria included the biathletes with (a) history of ankle, knee and back pathology in the last year (b) medications which would affect physical performance or balance ability (c) less than 90% attendance of all one-year training sessions (d) experience with any similar testing design of the study.

Twelve biathletes (5 girls, 7 boys) were recruited to the study (Girls: age 15.8 ± 0.74 years, body weight 55.20 ± 5.70 kg, body height 1.65 ± 0.03 m, VO_{2max} 54.62 ± 3.29 $ml.kg^{-1}.min^{-1}$, W_{max}/kg 4.8 ± 0.39; Boys: age 15.0 ± 0.75 years, body weight 57.42 ± 6.47 kg, body height 1.71 ± 0.07 m, VO_{2max} 65.3 ± 2.85 $ml.kg^{-1}.min^{-1}$, W_{max}/kg 4.9 ± 0.22).

Measurements

Preliminary graded exercise test to determine maximum oxygen uptake (VO_{2max})

The individual level of VO_{2max} was determined before the experimental measurements on a cycle ergometer (Lode Excalibur). The test started at the load of 1W/kg body weight (duration 4 minutes). After this, the test continued with an increase of 0.3 W/kg body weight every 60 seconds until voluntary exhaustion. The gas exchange was continuously measured through inhaled and exhaled air by breath (METALYZER®3B, CORTEX) system. Simultaneously, the concrete percentages of HR_{max} appropriate to the levels of exercise intensity were found out during this test.

Postural stability measurements

Measurements of the anterior-posterior sway of the centre of pressure were conducted by Foot pressure scan FootWork Pro. The measurements were performed in4 situations with a rifle during shooting. The postural stability measurement of biathletes was performed during standing with open eyes and bare foot.

Shooting performance and rifle stability measurements

The laser device SCATT Shooter Training System (version 6.074) was used to measure the shooting performance and stability of the rifle. A laser transmitter was fixed on the barrel of the rifle. For the purpose of measurement, the length trajectory of motion of the barrel was recorded in the last second before a shot.

Research design

At the beginning of the study, the biathletes were instructed to refrain from caffeine products and any strenuous exercise at least 48 hours prior to the experimental measurements. Firstly, the anterior-posterior sway of the centre of the pressure movements was performed during resting conditions (no previous physical load). Then, each biathlete warmed-up during an 8-minute lasting roller skiingat the self-selected pace (Figure 1). Subsequently, each biathlete carried out 3 series of 5 shots in the standing shooting position after a precisely controlled increasing physical load (each interval exercise consisted of 5 minutes lasting roller skiing in three levels of intensity, i.e. Intensity 1: 65-75%, Intensity 2: 75-85% and Intensity 3so-called anaerobic threshold: 85-95% of HR_{max}). The participants were encouraged to check their predetermined heart rate (the heart rate was measured by a sport tester Polar M400).The postural stability, the rifle stability and the shooting performance were measured during shooting on stabilometric plateau. It is important to mention that each athlete was instructed to shoot in his/her own-taught competition rhythm.

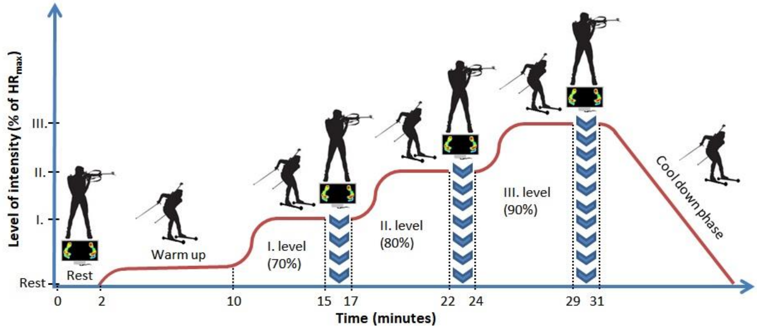

Figure 1. Research design

Statistics

All statistical analyses were performed using the Statistica 12.0.The data are presented as means with standard deviation. To account for interindividual characteristics, the rifle stability and the postural stability measurements are expressed as a percentage change from baseline.

Results

The improvement of the observed parameters was found out after the systematic one-year training in both boys and girls. The enhancement of the postural stability in standing shooting position during testing in rest was found in the group of boys by 15.4% on average and in the group of girls by 35.7% on average. An average progress of the same observed parameter during testing after a physical load was evident too: Intensity 1 - boys13.3%, girls 41.2%; Intensity 2–boys18.8%, girls 42.1%; Intensity 3 –boys 46.0%, girls 58.1% (Figure2-3). The stability of the rifle during testing in rest and after a physical load was also improved in both groups of the participants. The rifle stability in standing shooting position increased as follows: in rest –boys24.3%, girls6.2%; Intensity 1–boys19.5%, girls13.9%; Intensity 2 –boys1.8%, girls13.0%; Intensity 3–boys16.1%, girls17.1% (Figure4-5). The most direct indicator of shooting performance was a comparison of summary shooting results in July 2016 and July 2017 in groups of boys and girls separately. From year to year in the observed period the average shooting performance (the percentage of successfully hit targets) was improved from 46% to 67% in the boys group and from 56% to 71% in the girls group.

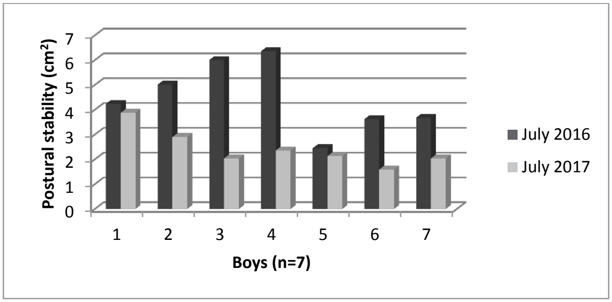

Figure 2. Postural stability in the boys group (July 2016, July2017)

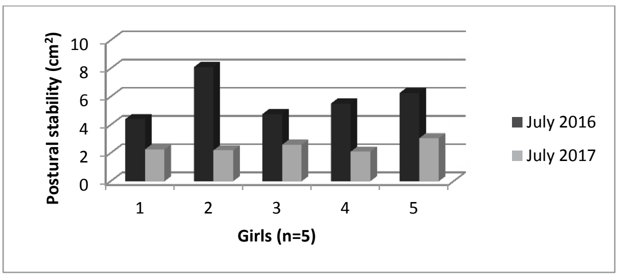

Figure 3. Postural stability in the girls group (July 2016, July2017)

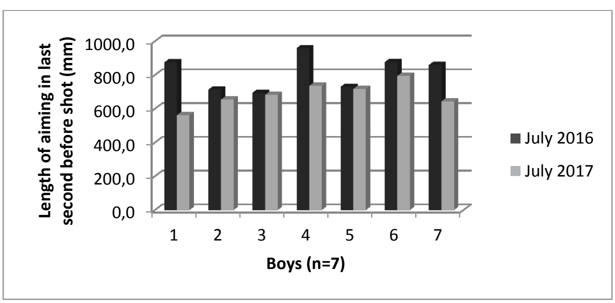

Figure 4. Length of aiming in the boys group (July 2016, July2017)

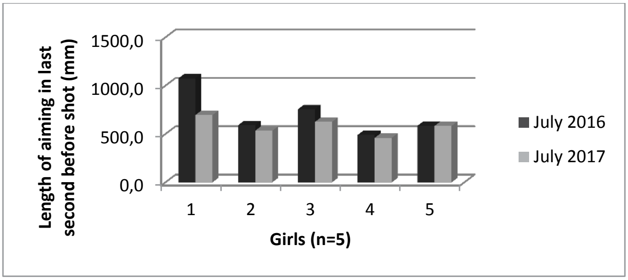

Figure 5. Length of aiming in the girls group (July 2016, July2017)

Discussion

The results showed that one yearof systematic training had a positive effect on shooting percentage performance of the young biathletes. The positive changes were detected in both the anterior-posterior sway and the length of aiming in the last second before a shot during the standing shooting position in all levels of exercise intensity. This improvement maybe the result of the development of strength abilities, the amount of shot bullets and the so called “dry shooting” training that were the three main components of the systematic training. The results proved a possibility to utilize the anterior-posterior balance and the length of aiming as indicators of the stability in standing shooting position and the stability of the rifle in biathlon.

We compared the results of our study with outcomes of many different researches. We confirmed the direct dependence of the postural stability on the shooting performance in the standing shooting position which is in accordance with the results of specific researches, especially by authors Groslambert et al. (2003), Mononen et al. (2006), Sattlecker et al. (2007), Straňák (2007) and Laaksonen et al. (2011). We agreed with more authors who regarded postural stability as a limiting factor of shooting in the standing position in biathlon and in shooting sport in general (Mononen et al., 2006; Sattlecker et al., 2007; Straňák, 2007; Ondráček, 2011; Vonheim, 2012; Baca & Kornfeind, 2012; Mojžíš & Paugschová, 2013). Straňák (2007) concluded that the stability of the standing shooting position is one of the main factors that affect shooting success. He added a statement that a significant part of the shooting success is represented by the intensity of the physical load before shooting. This statement was proved in our study just asin research of Mojžíš & Paugschová (2013). On the contrary, Vonheim (2012) did not confirm the fact that intensity of the physical load before shooting has a major impact on the final shooting performance. We agreed with the conclusion of studies of Straňák (2012), Mojžíš & Paugschová (2013) and

Vonheim (2012) that it is the physical load which affects the stability in the standing shooting position and the aiming process.

Finally, it is necessary to take into consideration the following limiting factors of our study. Firstly, only twelve participants completed all the measurements successfully. This low number was caused by the strict conditions of the selection of the athletes which were mentioned above. Moreover, it is not possible to compare the results of the boys group against the group of girls objectively because these groups did not have the same number of athletes. Secondly, the improvement of the shooting performance could be intensified thanks to the fact that the participants used the SCATT training system during the one-year training several times, which means they could get used to it. Thirdly, the roller skiing was used during the whole testing due to summertime but participants had to step on Foot pressure scan FootWork Pro only barefoot. It is clear that it was necessary to take off the skate shoes before each shooting. However, the effect on the overall results was not so large because the level of HR was controlled strictly and taking-off skate shoes lasted only 8 seconds maximally.

Conclusion

Our assumption of an improvement in the shooting performance after one yearof systematic training was proved. The onward, but not so significant, progress of shooting skills and other observed parameters (for example the individual level of VO_{2max}) during the next year can be expected if the same training concept is continued. To conclude, the participants' improvement in the shooting performance shows that the systematic training of the shooting skills in biathlon is necessary and meaningful. We are convinced that the utilising of the analogous methodology which we applied in our study (i.e. observing the shooting parameters thanks to the Foot pressure scan FootWork Pro and SCATT Shooter Training System continuously over time and the evidence of the results from this) should take place in a common training process. It would be very beneficial for both biathletes and their coaches as it might be a great instrument to monitor the progress of the athlete's shooting skills and the auxiliary instrument for prediction of the shooting performance in the race.

Acknowledgements

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ATHLETICS

THE EFFECT OF UNILATERAL STRENGTH TRAINING ON CROSS-COUNTRY SKIING DOUBLE POLING PERFORMANCE

Brűnn David, Sýkora Jozef, Pupiš Martin
Department of Physical Education and Sports, Faculty of Arts,
Matej Bel University in Banská Bystrica, Slovakia

Abstract

At the highest level of sports performance, further progress is already very limited. Therefore, it is very important to implement more new training approaches and methods to our training process. The main purpose of our research was to find out if unilateral strength training is more efficient for developing cross-country skiing double poling performance than traditional bilateral strength training approach. Our research sample consisted of 8 probands (Age 17.94 ± 1.04), national and international level cross-country skiers. The experimental group implemented a unilateral and the control group a bilateral strength training program within 6 weeks (3 training sessions per week). For tests we used SkiErg machine from Concept 2. The experimental group achieved improvement in total distance of about 6.66% (9.25 m) and control group 2.69% (3.75 m). Although we did not register a statistically significant difference between groups ($p = 0.724$), the experimental group improved its performance with medium effect size level ($p = 0.11$, $r = 0.4$), while the control group achieved a small effect size level only ($p = 0.19$, $r = 0.17$). The gap at the finish line between a winner and a loser in cross-country skiing is often just a few centimetres, so our result (difference of almost 6 meters between our groups) would make a big difference in real races.

***Key words**: Cross-country skiing, double poling, unilateral strength training*

Introduction

At the highest level of athletes' sport performance, progress is already very limited. Therefore, athletes and coaches have to look for other new or alternative training methods to increase their performance (Billat, 2001).

In our research, we wanted to find out how unilateral character of strength training will affect performance in cross-country skiing double poling technique. We would like to bring forward the answer whether cross-country skiers should use unilateral strength training in their training process or whether unilateral strength training will not affect their performance in a significant way.

Cross-country skiing is a very difficult sport when it comes to technique and coordination demands (Ilavský & Suk, 2005).

Cross-country skiing classic technique includes a few technique variations which we use according to a specific track profile or track sections (Bolek, Ilavský, Soumar, 2008). In today's cross-country skiing, we are dealing with a very specific case. Double poling skiing technique is now used not only for flat terrain but athletes are choosing this technique to compete also on very demanding courses (Brűnn, 2015). The double poling technique is becoming the phenomenon of this sport and a game-changing technique. When you are good at the double poling technique, you have the chance to win a race. If you are not good at it, you are only a tourist on skis.

Our theoretical base comes from describing the phenomenon of bilateral limb deficit. By this phenomenon, we mean the difference in maximal or submaximal force generated by muscles contracted alone or in combination with contralateral muscles. Bilateral limb deficit occurs when the summed unilateral forces are greater than the bilateral force (Kuruganti, 2005).

So far, we have seen unilateral training-based experiments on students, patients, volunteers and collective sports players but we lack practical research in our sport. In experimental group composed of students, Rube and Secher (1988) found almost the same increment in both unilateral and bilateral group. Furthermore, Lee, Kim, Park and Park (2017), were performing experiments on sick subjects where patients after stroke gained more benefits from bilateral training. Secondly, Botton et al. (2016) found that bilateral strength training positively affects strength in bilateral character of movement and unilateral strength training positively affects strength in unilateral character of movement. Skok et al. (2016) came up with the conclusion that unilateral strength training is more effective for collective sports and players should be using this approach.

We see these findings as a stepping stone and if we know the movement structure of any particular sport, we can also set up an effective way of improving the athletes' strength in that movement structure. In addition, it is very interesting that there is also a strength transfer from the trained to untrained limb (Derakhti, Akerlund, 2016; Schlenstedt, 2016; Taniguchi, 1998).

So far, we know that if we train in a unilateral way, we will be better in a unilateral movement structure. However, we still do not know if unilateral strength training approach also improves our performance in specific cross-country skiing double poling bilateral movement structure.

The main benefit of our research will be the direct application of our findings to the cross-country skiing training process. Cross-country skiers will know if unilateral strength training has any value for them and if it will make difference in races eventually.

The objective of our research was to find out if there is a significant effect of unilateral strength training on the cross-country skiing double poling performance.

Methods

The experiment was conducted from May 15, 2017 to July 10, 2017 for 8 weeks in total. The tests and the entire training process took place in OŠG Banská Bystrica.

Our research sample consisted of 4 male and 4 female probands (Age 17.94 ± 1.04), cross-country skiers, from OŠG Banská Bystrica. These athletes all compete on national and international level and, considering Slovak cross-country skiing possibilities, they also represent an adequate research sample.

After entry test, we divided our sample into two groups which were homogeneous in terms of performance level (Shapiro-Wilk test). Afterwards, we monitored the improvement of each group separately, differences between groups and intraindividual changes.

The experimental group underwent the unilateral strength training program and the control group the bilateral strength training program. The experimental stimulus was directly the unilateral strength training program.

Each training session was built on seven movement patterns based on strength training principles whose author is a well-known strength and fitness coach Michael Boyle. The probands were training in this program 3 times per week. Each session took one hour and fifteen minutes and took place on Monday, Wednesday and Friday.

During the first 4 weeks, we were developing eccentric strength in tempo 4:0:1 (eccentric phase: mid-point: concentric phase), 10 repetitions (first and second week) and 8 repetitions (third and fourth week). We had 4 series for bilateral and 3 series for unilateral group. During the second 4 weeks, we were developing maximal strength in tempo 2:0:1. In the first two weeks of this period, we decreased the number of repetitions to 6, but the number of series stayed the same as in the first four weeks. For the last two weeks of maximal strength development, we did 4 series in unilateral group and 5 series in bilateral group. The number of repetitions was 5 for both groups.

SkiErg from Concept 2 was used as the testing device. It was specifically created and modified for cross-country skiers. We evaluated power in Watts and total distance after 30 second maximum effort test with the data from this trainer. Both variables (Watts and metres) can be seen right on the display after your tests. Of course, both variables could have been affected by the weight of our proband, but the same thing happens in real conditions of cross-country skiing or any other sport.

On the basis of Shapiro-Wilk test, we used a parametric method of statistical significance evaluation. In our case, that parametric alternative was a paired t-test ($p \leq 0{,}05$) and our results were also supported by a calculation of effect size (Cohen's d). For statistic test calculation, we used Microsoft Excel 2016.

Results

The experimental group increased their average distance on SkiErg by about 9.25 m (48.5 W). The control group made improvement only by 3.75 m (11.75 W) in average. Therefore, the difference between these groups was 6 m (36.75 W).

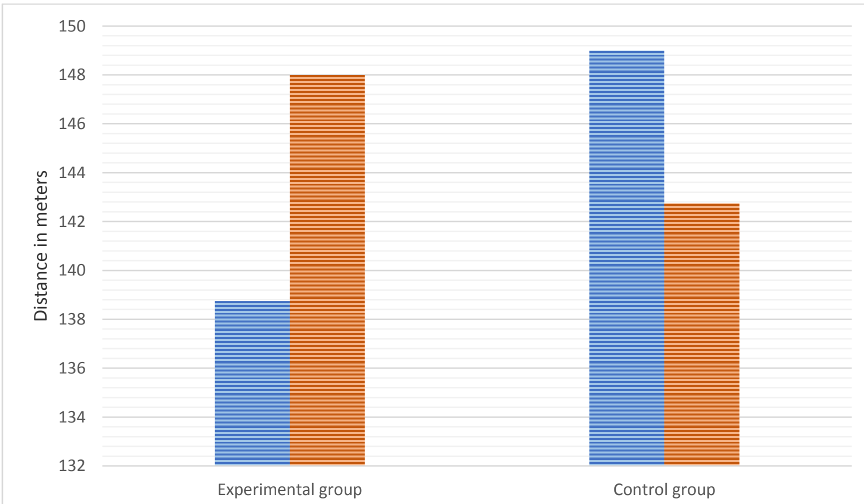

Figure 1. Average completed distance on SKIERG for both groups.

To put it in statistics, the value of statistical significance (p) was 0.724 between the final tests of both groups.

Additionally, there is no evidence about statistically significant improvements in each group separately, either. For the experimental group (p) was 0.11 and for control group 0.19.

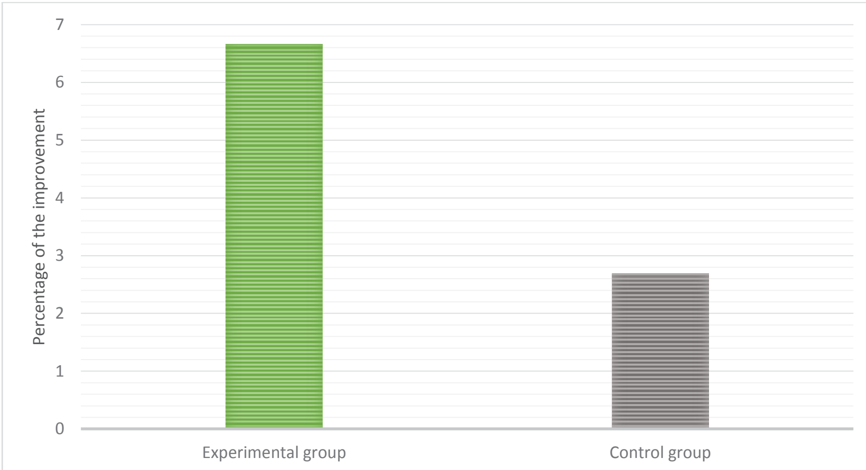

Figure 2. Percentage of total distance improvement of both groups

The experimental group increased its performance by about 6.66%, which translated to almost 6 meters' improvement in the total completed distance.

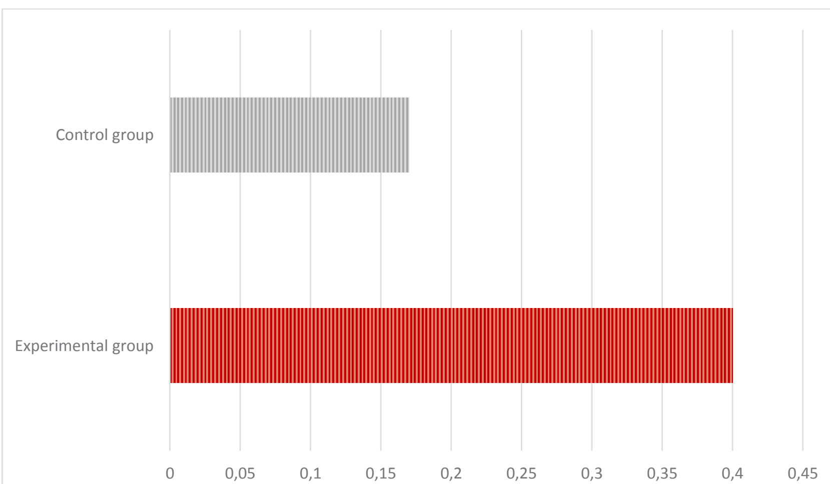

Figure 3. Effect size (Cohen's d)

Due to small statistical significance, we calculated the effect size of the experimental group improvement (r = 0.4), which can be interpreted as a medium effect of experimental stimulus.

Discussion

Before our experiment, we knew that if we train in a unilateral way, we will be better in a unilateral movement structure. On the other hand, we did not know if unilateral strength training approach will also improve our performance in the specific cross-country skiing double poling technique.

On average, the difference of completed distance between the experimental and the control group amounted to almost 6 m. You can see almost identical starting point for both groups but a totally different final result. Statistical significance (p) was 0.724. Since it is more than 0.05, we can state that we have not registered significant changes in the athletes' performance level. We credit this fact to the low number of probands and not to the quality of the experimental stimulus.

Despite the fact that our results were not statistically significant, the experimental group increased its performance by about 6.66% (9.25 m) and we registered a medium effect size ($p = 0.11$, $r = 0.4$) of the experimental group's improvement. This is definitely significant in real conditions where the gap on the finish line between a winner and a loser in cross-country skiing can often be only a few centimetres.

We can now proclaim that the experimental group made a significantly greater improvement in terms of total distance and power than the control group. Despite the fact that we cannot confirm statistically significant changes between groups but only for each group separately, we can state that our results are significant in real world of racing and that the unilateral strength training approach also improved the performance in a specific movement structure.

Conclusion

Unilateral strength training approach has a greater effect on performance enhancement for our specific purpose than bilateral strength training approach.

Even though we have improved our athletes' performance and we are making conclusions for real world conditions, we also have to consider possible deviations which could have been caused by our testing device. We cannot be sure if the distance recorded on our trainer is the same as it could be on snow. What we can confirm and prove is the power improvement on the same trainer of both groups at the beginning and at the end of our experiment.

That brings us back to the start when we asked ourselves if it would be more efficient for cross-country skiers to do unilateral strength training compared to bilateral. According to our results, it seems that unilateral strength training might create better transfer to double poling cross-country skiing technique than bilateral strength training.

Acknowledgements

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EFFECTS OF A PHYSICAL PROGRAM ON INDICATORS OF PHYSICAL DEVELOPMENT AND PERFORMANCE IN 6 & 7 YEAR OLD CHILDREN

Čillík Ivan, Willwéber Tomáš
Department of Physical Education and Sports, Faculty of Arts, Matej Bel University, Banská Bystrica, Slovakia

Abstract

In this contribution, we present the changes in the physical development and movement performance of 6-7-year-old children as a result of a movement program within the IAAF Kids' Athletics project.

The monitoring period was 5 months, during which the members of the experimental set went through 37 training sessions (2 training sessions for 60 minutes a week). The physical program consisted of preparatory athletic and gymnastic exercises and cardio games. Versatility training was focused on the development of all fitness abilities, coordination abilities and articulated mobility. The experimental group consisted of 24 children (17 boys and 7 girls), aged 6.62 ± 0.31 years. The control group consisted of 31 children (22 boys and 9 girls), aged 6.78 ± 0.3 years. The body height, body weight and body mass index were measured from physical development indicators. To measure fitness, the following tests were used: standing long jump, knee throw overhead, 4 x 10 m shuttle run, frequency of lower limbs for 6 seconds and an endurance shuttle run.

Following the assessment of the results, the research showed that all tests used, except BMI, used showed statistically significant differences ($p < 0.05$). In BMI, a decrease in the experimental group was noticed and an increase in the control group. Within the control group, statistically significant changes occurred in 1 out of 5 tests applied (knee throw overhead) on the level ($p < 0.05$). Tests of standing long jump 4 x 10 m shuttle run, endurance shuttle run and frequency of lower limbs showed no statistically significant difference. In the control group, minor changes were noticed in physical development and movement performance in the same way as in the experimental group, with statistically significant differences.

The results show that children who attended the IAAF Kids' Athletics project achieved positive changes in physical performance and in BMI.

Key words: *Kids' Athletics, somatic parameters, physical development, young-school age*

Introduction

Athletics provides a wide range of possibilities for coordination skill and physical fitness development that significantly enhance the development of fundamental motor skills. Fundamental motor skills in athletics include elementary movements such as run, leap, throw and their various combinations (Hirtz, 1997).

No one can deny the positive effects of athletics on fundamental motor skills development. Since in pre-school, but especially at the young school age, the movements are differentiated and the continuity of movements is applied, it is appropriate to use a wide range of athletic exercises and games at this age. Athletics uses specific training resources enabling children to get a sense of how to perform them correctly (Doležajová, Koštial & Lednický, 2009).

Gerstner (2010) mentions the important objectives of the IAAF Kids' Athletics project, including all-round physical exercises, health promotion, social interaction and team fun. The project is based on competitions with modified athletics' tools, realized in the form of games.

The IAAF Kids' Athletics project draws upon the knowledge of various authors engaged in the training of children of pre-school and young school age. Wiart and Darrah (2001) state that children in the early phase of young school age are well placed to deal with combined physical activities. Children are adequately prepared to handle activities that require a short but intense load, as well as a longer, less-demanding load (Schiffer, 2013).

Regarding to the increase of the level of physical performance, the emotional and diverse satisfaction of the child is dominated by the high level of versatility in sports training.

According to authors Sabau, Niculescu, Gevat and Elena (2013), subjective factors such as improvement of stereotyped movements, higher fatigue resistance, better motor coordination etc., often indicate the individual training experience of children.

There is a difference regarding the number of years of physical training relative to the overall focus on developing skills in training and the proportion of general and special training.

Various authors (Myer, Lloyd, Brent, & Faigenbaum, 2013) recommend the ratio of general and specific training 70%: 30% during the first years of training. A similar ratio and result were stated in the research of Čillík and Švachová (2014). Generally, speed drills and coordination skills are the priorities when training children (Perič, Petr, & Lavitová, 2008).

The aim of this report is to point out the changes in the level of physical development and movement performance of 6-7 year old children as a result of following the movement program within the IAAF Kids' Athletics project.

Methods

Research participants were children of young school age. This experimental sample consisted of 24 children (17 boys and 7 girls) aged 6.62 ±0.31. At the beginning of the research, the following somatic characteristics were measured: average body height 122.69 ±5.12 cm, body weight 23.65 ±3.58 kg and body mass index 15.65 ±1.62 kg.m^{-2}. The control sample consisted of 31 participants (22 boys and 9 girls) aged 6.78 ±0.3. The initial somatic characteristics were: body height 124.27 ±4.03 cm, body weight 24.87 ±4.27 kg and body mass index 16.03 ±1.92 kg.m^{-2}.

The experimental factor was the physical program within the IAAF Kids' Athletics project. The experimental period lasted for 5 months and participants undertook 37 training sessions. Children attended 2 training sessions per week lasting for 60 minutes each. The training focused on the optimal development of fitness and movement skills. Efforts were made to carry out training with a ratio of general and specific preparatory training of 70:30 (Fig. 1).

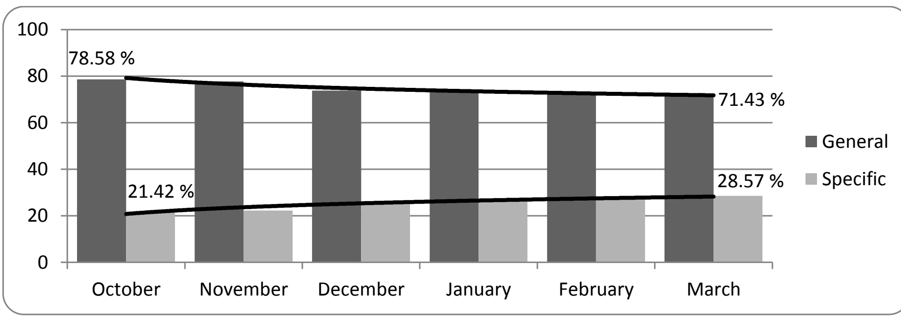

Figure 1. Ratio of the general and specific preparatory training during the experimental period

General – We record time spent on motor games exercises to develop general movement performance, gymnastic exercises, as well as the time spent on stretching exercises and stretching.

Specific – We record the time spent on running exercises, relay training exercises, jumping exercises, exercises for throws.

The level of fitness abilities was measured by using the following tests: standing long jump, knee throw overhead, 4 x 10 m shuttle run, frequency of lower limbs in 6 seconds and endurance shuttle run.

Standing long jump, a test to assess lower limb explosive power was based on the methodology of Moravec, Kampmiller, Sedláček, et al. (2002).

Knee throw overhead test was used to find out the explosive power of the upper body and trunk (Šimonek, 2015). The test was modified according to the age of the children, so a volleyball ball (weight 250g) was used instead of a medicine ball (1kg). Shuttle run 4 x 10 m (Čillík, Kollár, Kremnický, et al. 2014) was carried out to measure speed with a change of direction. Brown (2001) recommends this test for selecting talent in the given age category.

Frequency of the movement of lower limbs was monitored by FiTRO tapping check diagnostic system (FiTRONiC, Bratislava, Slovak Republic). The task of the person was to touch, as many times as possible, with either the left or the right foot, the contact switch mats within the period of 6 seconds. The system measures contact and flight times in milliseconds, and calculates the cycle time and the corresponding tapping frequency. Out of two attempts, the better result was recorded. According to the methodology of Moravec, Kampmiller, Sedláček, et al. (2002) an endurance shuttle run was used to assess endurance skills.

Basic mathematical and statistical indicators were applied to calculate the arithmetic mean, standard deviation, minimum and maximum. Normal distribution of the data was calculated using the Shapiro-Wilk test. A two-way repeated measures ANOVA was applied to analyze the between-group (Control and Experimental) and within-group (pretest and posttest) effects. Moreover, the effect size (η^2) for analysis of variance was calculated. Partial eta squared values of 0.01, 0.06 and 0.14 were interpreted as small, medium and large effect sizes, respectively. Calculation of statistical significance was set at the level $p < 0.05$.

Results

The following somatic parameters: body height, body weight, body mass index, as well as the parameters of movement skills (Tab. 1) were measured to determine the efficiency of the athletic programme within the experimental and control group.

Within the experimental group, body height increased by 2.95 cm (2.41%) and body weight by 1.08 kg (4.58%). Body mass index decreased by 0.05 kg.m^{-2} (0.29 %) - of no significant difference.

Within the control group, an increase in body height was recorded of 2.06 cm (1.66 %) and in body weight of 1.73 kg (6.95%). These parameters represent a statistically significant difference ($p < 0.05$). Body weight increased by 0.56 kg.m^{-2} (3.52 %) which represents a statistically significant difference ($p < 0.05$).

Table 2. Results of the somatic parameters and movement skills in the experimental and control group

	Experimental group			Control group			Differences	Effect Size (η^2)
	Pretest	Posttest	M Dif.	Pretest	Posttest	M Dif.		
BH [cm]	122.69 ± 5.12	125.64 ± 5.57*	2.95	124.27 ± 4.03	126.33 ± 4.4*	2.06	t	0.624
BW [kg]	23.65 ± 3.58	24.73 ± 3.85*	1.08	24.87 ± 4.27	26.6 ± 4.7*	1.73	t	0.442
BMI [$kg.m^{-2}$]	15.65 ± 1.62	15.61 ± 1.60	-0.05	16.03 ± 1.92	16.59 ± 2.1*	0.56	g-t	0.214
SLJ [cm]	118.79 ± 20.03	126.92 ± 18.28*	8.13	117.74 ± 16.82	122.94 ± 15.7	5.19	t g-t	0.563 0.379
KTOH [m]	4.18 ± 0.94	4.64 ± 0.81*	0.47	4.35 ± 0.84	4.67 ± 0.9*	0.33	t g-t	0.372 0.238
4 x 10m [s]	14.29 ± 1.49	13.58 ± 0.98*	-0.71	14.34 ± 1.2	14.31 ± 1.11	-0.03	t g-t	0.426 0.318
ESR [n]	18.25 ± 9.35	24.92 ± 10.58*	6.67	16.13 ± 8.3	19.77 ± 10.6	3.65	t	0.572
FLL [n]	35.71 ± 9.24	39.13 ± 6.97*	3.42	33.97 ± 6.96	34.45 ± 10.9	0.48	t	0.784

*Legend: BH – body height; BW – body weight; BMI – body mass index; SLJ – standing long jump; KTOH – knee throw overhead; shuttle run 4 x 10 metres; ESR – endurance shuttle run; FLL – frequency of lower limbs; t – time interaction; g-t – group-time interaction; * – statistical significance p < 0.05*

Table 1 shows that for probands there was a time (t) interaction in all the variables, except BMI, so during the period of 5 months both groups achieved significant improvements in their physical development and performance, but not in BMI.
Regarding group-time interaction, it is observed that changes in 4 variables of the experimental group differed from the control group. Therefore the probands of the groups improved after the period of 5 months, but the experimental group achieved more improvements, especially in SLJ, 4 x 10 m, ESR, FLL. Besides, in the experimental group there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in the control group there were significant pre to post changes at $p < 0.05$ only in 4 variables (BH, BW, BMI and KTOH). With reference to mean differences, it is remarkable that 4 x 10 m reduction in experimental group was -0.71 s, while in control group it was only -0.03 s. Further, effect size values suggested large practical significance in all the variables, with the highest effect size in FLL time interactions (0.784).

Discussion

The results of our research indicated that in the experimental group there were significant pre to post changes at $p < 0.05$ in all the variables (with the exception of BMI), while in the control group there were significant pre to post changes at $p < 0.05$ in only 4 variables (BH, BW, BMI and KTOH).

The results of physical development (BH, BW and BMI) from the point of view of linear growth comply with the PHASR (2013) programme. In comparison with the national average, the experimental group as well as the control group, achieved considerably lower BMI values. The result may have been caused by a smaller increase of body weight during the experimental period due to their participation in the training programme.

Appropriate body composition parameters may contribute to achieving an optimal level of physical performance. According to Mayooran, Attygalla and Subasinghe (2014), body composition is one of the fundamental parts of physical fitness.

The results align with the previous findings within a group of older children aged 8 – 9 years (Čillík, & Švachová, 2014). At the end of the 8-month experimental period, statistical changes occurred in all tests of physical performance, except in the test of bent arm hanging.

According to the Balyi, & Hamilton (2004) research, optimal conditions for the development of speed drills are to be found during the period of young school age (6-8 year old girls and 7-9 year old boys). This statement was supported by the experimental group in this research.

Zapletalová (2002) found a significant improvement in speed drills during the period of the young school age. The same results were found in our research as our experimental and control group achieved a certain level of improvement of physical performance.

Comparing our results with the previous research of Čillík, Kremnický, Kollár, & Mandzáková (2016) shows a lower level of physical development indicators in both the experimental and the control group as compared with the pupils of the 1st grade in the Banská Bystrica region. Their average body height was 125.89 cm, body weight 26.37 kg and body mass index 16.47. In terms of general physical performance, both the experimental and control group achieved better results in output performance as compared with the pupils of the 1st grade in Banská Bystrica region. The results in the standing long jump were 116.25 cm, 14.87 s in the shuttle run test and average performance 19.42 / distances covered in the endurance shuttle run.

Our research indicated that increasing the number of aerobic activities results in better movement performance, as well as in a slight decrease of BMI. The same results were reported by López-Sánchez, Díaz-Suárez, Radzimiński, & Jastrzębski (2017) in an experiment with 11 and 12-year-old children. The experiment lasted for 12 weeks (15-minute sessions, 3 times a week) and resulted in a slight decrease of BMI and body fat.

Conclusion

The results of this research show the changes in the general performance of children aged 6 to 7 who attended athletic preparation training. The IAAF Kids' Athletics project provided positive effects on the improvement of average performances in all tests applied.

Following the assessment of the results using mathematical and statistical methods, the research showed that all tests, except BMI, used showed statistically significant differences ($p < 0.05$). Within the control group, statistically significant changes occurred in 1 out of 5 tests applied (knee throw overhead) on the level ($p < 0.05$). Tests of standing long jump 4 x 10 m shuttle run, endurance shuttle run and frequency of lower limbs showed no statistically significant difference.

The research showed that children attending the training programme achieved positive changes in their body mass index and in indicators of physical performance. It was shown that this training programme generates reliable results in a group of 6 and 7-year-old children after 5 months.

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THE ROLE OF THROWING EVENTS IN DECATHLON – ANALYSIS OF ABSOLUTE AND POINT RESULTS

Dziadek Bartosz[1], Iskra Janusz[2], Pietrzak Michał[3], Przednowek Krzysztof[1]
[1]University of Rzeszow, Faculty of Physical Education, Poland
[2]Opole University of Technology, Faculty of Physical Education and Physiotherapy, Poland
[3]The Academy of Physical Education in Katowice, Poland

Abstract

Purpose: Decathlon is a combined track-and-field event in which an athlete's final result depends on the partial results achieved in each of the ten component events, which include running, jumping and throwing. The aim of this paper was to analyse the significance of throwing events for the final score in decathlon at various stages of development of an athlete's career, taking into account the point score. The analysis was conducted on the basis of data collected on the careers of the world's 25 best athletes active between 1985 and 2015 (282 cases).

Methods: The material was divided into the four stages of the career development (S1 – to 19 years of age, S2 – form 19 to 23 years of age, S3 – form 23 to 30 years of age and S4 – from 31 years of age to the end of the career). The study takes advantage of basic descriptive statistics, determines the values of Pearson's linear correlation coefficients, ANOVA variance analysis and post hoc Tukey's test. All analyses were conducted using the Statistica 12 software and the R programming language, along with additional packages.

Results: The research shows that there are statistically significant differences between levels achieved in individual throwing competitions in most career stages. In addition, significant relationships between the various competitions at different stages of the ontogenesis of the athletes are observed. The calculations proved the existence of statistically significant correlations between the final score in decathlon and the point scores in throwing events, and of correlations between individual events at various stages of a decathlete's sport development.

Conclusions: On the basis of the obtained calculations it was concluded that results achieved in discus throw and shot put events at junior stage have the highest significance for and influence on the final results and the high correlation between shot put and discus throw might be significant in terms of combining training units. Javelin throw should be treated independently – it does not reveal any connection with other throwing events regardless of the career stage.

***Key words**: decathlon, throwing competitions, sport ontogenesis*

Introduction

The modern decathlon consists of ten different events held over two days on a track and field stadium. Competitors in this demanding combined event take part in running, jumping and throwing events and their best scores are converted into points and summarised. Partial results are converted into points using scoring tables for combined events, which were last modified in 1985 (Edouard, Mori, Samozino, 2013; Kuijen, 2012; Quercetani, 2000; Trkal, 2003).

The results achieved in decathlon rely on the high level of motor (strength, speed, endurance), technical and personal abilities of the competitors (Jerabek, 2003).

Events which typically focus on speed include 100 metres, 400 metres, 110 metres hurdles and long jump. In throwing and jumping events competitors rely on strength and in 1500 metres on endurance. The sheer number of events, their diversity and complexity, as well as the difficult and distinctive training process make decathlon one of the most difficult track and field events.

The throwing competitions in decathlon, i.e. shot put, discus throw and javelin throw are technical competitions with a focus on speed-over-strength or strength-over-speed. The final score is largely determined by the competitor's somatotype (height and weight), strength and speed abilities and the throwing technique.

Most decathletes are best at speed and rely on their results in running competitions (100 metres, 400 metres and 110 metres hurdles) and long jump (Poliszczuk 2001). Those who are best at strength and achieve significant results in shot put and discus throw, are a rare group of decathletes, who were found mainly in the past.

The world history of decathlon has seen competitors with outstanding achievements in throwing competitions. Before World War 2 world records in decathlon were broken by the German Hans-Heinrich Sievert, who was also Germany's top thrower. Outstanding results in shot put and discus throw were also achieved by the 1960s record-breaker, Russ Hodge (over 17 m in shot put and over 50 m in discus throw). In javelin throw, a special competition for decathletes, results over 70 m were achieved by the world record breaker Kurt Bendlin and Olympic medallist Leonid Lytvynenko (Hymans, Matrahazi 2015).

The significance and impact of individual component events on the final result can change at specific stages of an athlete's development (Nowak, 1989). The impact and significance of running ability and the level of jumping skills of the world's best athletes for the total result in decathlon at various stages of development was the subject of earlier research (Dziadek, Iskra, Przednowek 2016b, 2016c, 2016d).

The objective of this paper was to determine the significance of throwing events for the final score in decathlon on the basis of an analysis of the careers of the world's best athletes active between 1985 and 2015, taking into account the stages of their career development and the point score.

Material and methods

The analysis of the significance of throwing competitions for the final score in decathlon took into account actual performance, point scores and final scores achieved by world's 25 best athletes active between 1985 and 2015, which were assigned to the identified stages of the competitors' sport development. The data taken into account in the analysis contained information on 282 best person-appearances recorded in every year of each competitor's career in the studied group. The data were collected using the results database made available by IAAF (IAAF, 2016), the database published on www.decathlon2000.com (Salmistu, 2016) and the publications of track and field statisticians (Kuijen, 1998; Matthews, 2013). The collected data were assigned to 4 career stages:

– 1st stage (S1, junior athlete) – under 19
– 2nd stage (S2, young athlete) – from 20 to 23 years of age
– 3rd stage (S3, champion) from 24 to 30 years of age
– 4th stage (S4, reduced performance) from 31 years of age until career end

Descriptive statistics, such as group size, mean and standard deviation were used to describe and characterise the analysed data expressed in metres and points. The analysis of variance (ANOVA) and Tukey's post hoc test were used to determine the statistically-significant differences at various stages of career development for absolute and point scores. Pearson's linear correlation coefficient was used to evaluate the significance of individual throwing events for the final score in decathlon (rxy). The studies assume statistical significance (an element of correlation assessment specifying calculation reliability) at 0.05 (Stanisz, 2006, StatSoft, 2006).

All analyses were conducted using the Statistica 12 software and the R programming language, along with additional packages (R Core Team, 2016; StatSoft, 2014).

Results

Basis statistics were determined to characterise the respective throwing events at specific stages of career development of world's best athletes (Tab. 1). By analysing the obtained mean scores (distance and point score) it was observed that athletes had their best results in shot put ($\overline{x}$ = 15.57 m and $\overline{x}$ = 825 pt.) after 31 years of age. In the remaining two events, i.e. discus throw ($\overline{x}$ = 46.78 and $\overline{x}$ = 804 pt.) and javelin throw ($\overline{x}$ = 62.43 m and $\overline{x}$ = 775 pt.), competitors achieved their best results at the third stage of their development, i.e. between 24 and 30 years of age.

Table 1. Basic statistics

STAGE	shot put $\bar{x} \pm sd$		discus throw $\bar{x} \pm sd$		javelin throw $\bar{x} \pm sd$	
	[m] (p=0.0001)	[pt] (p=0.0001)	[m] (p=0.0001)	[pt] (p=0.0001)	[m] (p=0.0001)	[pt] (p=0.0001)
S1 (N = 33)	12.61±1.19	643±72	37.98±4.24	624±85	51.96±6.73	618±100
S2 (N = 81)	13.85±1.02	719±62	43.04±3.52	727±72	58.80±6.08	720±92
S3 (N = 131)	15.22±0.91	804±56	46.78±3.54	804±73	62.43±5.60	775±84
S4 (N = 38)	15.57±0.86	825±53	46.43±2.74	797±57	61.57±7.24	762±109

It was demonstrated on the basis of analysis of variance that there are significant statistical differences for all three throwing events at respective stages of career development. Using Tukey's post hoc test for non-equal values it was analysed between which groups there were significant differences in means for actual results and point score. The post hoc test demonstrated that at most career stages athletes achieve significantly different levels in these events. This fact is confirmed by the analysis of absolute values and point values. It is also significant that in no case was there a significant difference between the final stages of career, which might suggest that the level of athletes in throwing events becomes stable at the third career stage and remains at a similar level later (Fig. 1).

Pearson's linear correlation coefficients were determined to evaluate the significance of individual throwing events for the final score in decathlon. All the obtained results were calculated with a significance of 0.05. Table 2 presents the correlations between throwing events and the final result without taking into account the stages athletes' sport development. The results were similar and the highest correlation value was identified for shot put (rxy = 0.68).

Table 2. Correlations between the results in throwing events and the final score in decathlon

	shot put	discus throw	javelin throw
r_{xy}	0.68	0.66	0.62
p	0.00*	0.00*	0.00*

* statistical significance at α=0.05

The above analysis also takes into account the assumed stages of career development (Tab. 3) and determines the statistically significant values of Pearson's correlation coefficient. The highest significance for the final result in decathlon was observed at the first stage of career development for discus throw and shot put events (strong correlation at the level rxy = 0.7). At the second stage of career development, when athletes are 20 to 23 years of age, the significance of the three throwing events for the final score is lower and is within the range (0.5; 0.55). At the champion stage and in the period directly following it, the highest Pearson's correlation coefficients were determined for javelin throw, which amounted to rxy = 0.44 and rxy = 0.41 respectively. By comparing the mean results achieved in shot put (Tab. 1) and the determined correlation values (Tab. 3) at the respective stages of sport development, it was found that despite the fact that athletes achieved the best mean results in this event at the final (4th) stage of their career, they did not have a significant impact on their final result.

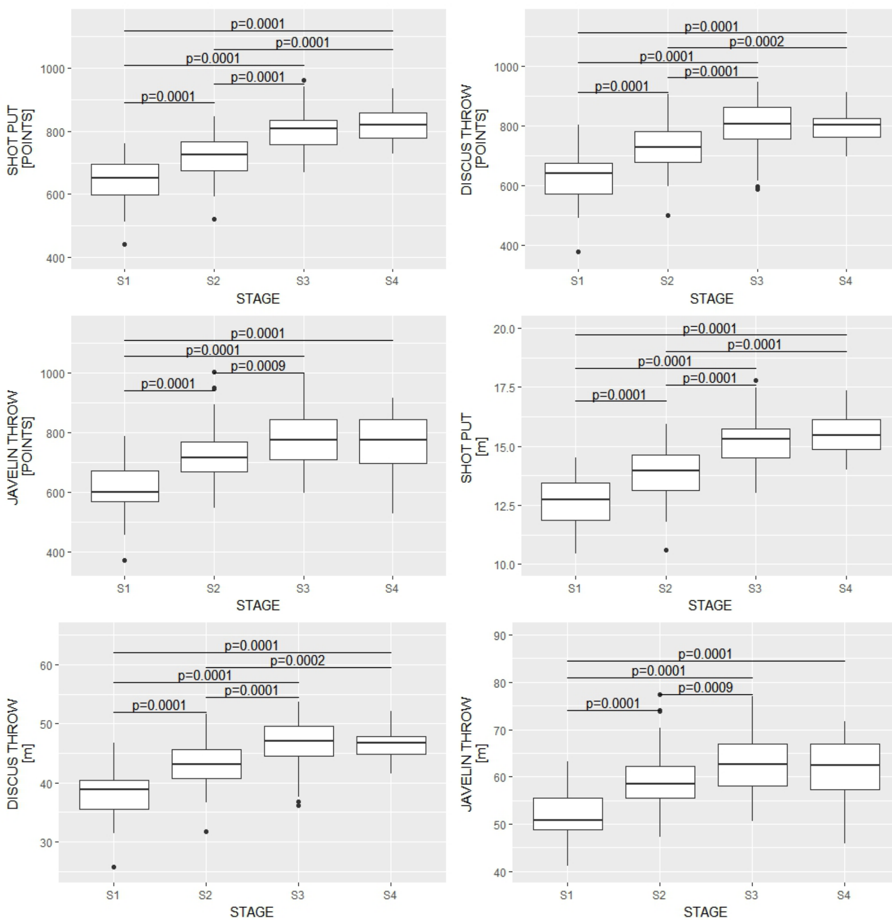

Figure 1. Results in throwing events at analysed stages.

Table 3. Correlations between the results in throwing events and the final score in decathlon, taking into account the stages of career development of world's best decathletes.

EVENTS	shot put		discus throw		javelin throw	
STAGE	r_{xy}	p	r_{xy}	p	r_{xy}	p
S1	0.70	0.00*	0.72	0.00*	0.54	0.00*
S2	0.55	0.00*	0.51	0.00*	0.50	0.00*
S3	0.26	0.00*	0.14	0.10	0.44	0.00*
S4	-0.05	0.78	0.19	0.27	0.41	0.01*

* statistical significance at α=0.05

Table 4. Correlations between individual events.

EVENTS	shot put		discus throw		javelin throw	
	r_{xy}	p	r_{xy}	p	r_{xy}	p
shot put	1.00	---	0.66	0.00*	0.40	0.00*
discus throw	0.66	0.00*	1.00	---	0.27	0.00*
javelin throw	0.40	0.00*	0.27	0.00*	1.00	---

* statistical significance at α=0.05

Table 5. Correlations between individual events, taking into account the career development stages of world's best decathletes.

STAGE	EVENTS	shot put		discus throw		javelin throw	
		r_{xy}	p	r_{xy}	p	r_{xy}	p
S1	shot put	1.00	---	0.64	0.00*	0.32	0.07
	discus throw	0.64	0.00*	1.00	---	0.21	0.24
	javelin throw	0.32	0.07	0.21	0.24	1.00	---
S2	shot put	1.00	---	0.62	0.00*	0.26	0.02*
	discus throw	0.62	0.00*	1.00	---	0.18	0.10
	javelin throw	0.26	0.02*	0.18	0.10	1.00	---
S3	shot put	1.00	---	0.60	0.00*	-0.02	0.84
	discus throw	0.60	0.00*	1.00	---	-0.06	0.47
	javelin throw	-0.02	0.84	-0.06	0.47	1.00	---
S4	shot put	1.00	---	0.28	0.09	0.01	0.96
	discus throw	0.28	0.09	1.00	---	-0.14	0.42
	javelin throw	0.01	0.96	-0.14	0.42	1.00	---

* statistical significance at α=0.05

Due to time limitations and the complexity of decathlon, an athlete's training cannot be the sum of training in the ten individual competitions (Socha, 1977). Taking this into consideration, looking for correlations between the respective component events might be significant. For this reason, it was analysed whether there were correlations between the individual throwing events and at what level they existed. In analysing all appearances of decathletes in the studied group, statistically significant correlations between the events were determined (Tab. 4), where the largest correlation was determined for shot put and discus throw (rxy = 0.66). In addition, the calculations involved the assignment of data to the career development stages of decathletes (Tab. 5). The results shown in table 5 demonstrate that the highest and most statistically significant Pearons's linear correlation values were determined for the three first stages of career development (until 30 years of age) for shot put and discus throw events. A weak correlation between the point scores for results in javelin throw and shot put events was observed at the second stage. There were no significant correlations between results in throwing events at the final stage of career development, which involved results of athletes over 31 years of age.

Discussion

Decathlon is a track and field event in which the final score depends on the results achieved in each of the component events (running, throwing and jumping) converted into points and their total. In the history of this combined event, record results have very often been achieved by athletes who had good results in some events and outstanding results in a certain group of events. In 1992 the US athlete Dan O'Brien improved his personal best results in three throwing events and long jump, achieving the result of 8891 and breaking the world record. The current world record holder, Ashton Eaton, achieves international-class results in short runs and long jump (Hymans, Matrahazi, 2015; IAAF, 2017).

The type of athlete who excels at running or throwing and relies on outstanding results in running or jumping events was characterised by Stemmler and Bäumler (2005).

An analysis of the development and course of the careers of modern athletes participating in decathlon events (1985-2015) in Poland and globally demonstrated that the development of results in each component event should be considered (Dziadek, Iskra, Przednowek 2016a). Similar conclusions were drawn by Nowak (1989), who claims that the significance of component events changes with an athlete's career development. For this reason, the current and previous studies take into account the respective stages of sport development.

It is demonstrated that running abilities in 110 metres hurdles and 400 metres have the highest significance for and impact on the final result (Dziadek et al. 2016b, 2016c). Long jump, similarly to all throwing events, is an event with a focus on speed-over-strength, which has a significant impact on the total score in decathlon (Dziadek et al. 2016d).

The high significance of shot put and discus throw at the first stage of career is probably linked to the early stage of the training process, which mainly shapes the athlete's strength and speed (Ryba, Mierzejewski, 2007; Shuravetsky, 2008).

In the entire career there is a moderate correlation between the results achieved by decathletes in javelin throw and the final result. In this event, the distance achieved is influenced mainly by mastering and applying the technique at each stage of the throw, and the time needed for learning the technique is limited in decathletes. According to Krzesinski (1986) javelin throw is one of the three events (in addition to pole vault and hurdles), which should be emphasised at the early stage of training, as these elements also impact on other component events.

Conclusions

The following conclusions were drawn from the analysis:

– Throughout an athlete's career development the results achieved in discus throw and shot put at the junior stage have the most significance for and impact on the final score. At further stages, the correlations between the result and specific events become weaker.

– The high correlation between shot put and discus throw at the first three stages (until 30 years of age) may be significant due to the possibility to combine training units.

– Javelin throw should be treated independently – it does not reveal any connection with other throwing events regardless of the career stage.

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RELATIONSHIP BETWEEN THE ISOKINETIC STRENGTH OF THE KNEE FLEXORS, KNEE EXTENSORS, AND SPRINT RUNNING PERFORMANCE IN ELITE FOOTBALL PLAYERS

Hlavoňová Zuzana, Cacek, Jan, Kalina Tomáš, Bokůvka, Dominik, Hammerová Tereza
Faculty of Sports Studies, Masaryk University Brno, Czech Republic

Abstract

This paper focuses on identifying the relationship between the isokinetic strength of the knee flexors, extensors, their ratio H/Q, and sprint running performance in elite football players. The strength of knee flexors and extensors (dominant limb) was tested using isokinetic dynamometer at angular velocities of 60 and 240°.s^{-1} on fourteen football players (excluding goalkeepers) of the highest Czech league. The only significant relationship was between the strength of knee extensors at an angular velocity (240°.s^{-1}) and the 30m running performance (r = -.0594), p = 0.025. A significant correlation ($p < 0.05$) between the isokinetic strength of knee flexors and extensors at an angular velocity of 60°.s^{-1} and 10m and 30m running performance was not detected. The relationship between the strength of knee extensors and 10m run as well as between the strength of flexors and 10m and 30m runs at the 240°.s^{-1} angular velocity was not detected.

***Key words**: Strength, concentric contraction, angular velocity, isokinetic dynamometer, flexor of the knee, extensor of the knee, relationship*

Introduction

Strength is an important component of sport performance in all kinds of sport, including football. To a significant extent, the speed of the movement is dependent on the strength, and it significantly influences the physical activity of players requiring skills, endurance, and resilience in personal contests during competition. Modern, professional football is a sport in which fast-moving individuals are successful. When it comes to the main components of a football player's condition, the greatest emphasis is placed on the start speed and running acceleration, explosive and quick strength, anaerobic and aerobic endurance (Psota et al.).

Christou et al. (2006) confirms that if strength training is added to regular training, it improves the maximum strength, height of vertical jump and the running speed per 30m.

The most frequent sprints performed during a match are at the distance up to 30m. Over the last decade, emerged studies that document the correlation between half squat performance and 10m and 30m running time. The study by the authors Wisloff et al. (2004) points to a strong correlation between maximum strength (squat) and 10m and 30m sprint in 17 elite footballers. Moreover, a highly significant relationship between the percentage change of relative 1RM (squat) and 5m, 10m and 20m sprint is found in 17 elite footballers by William et al. (2015). McBride at al. (2009) studied the relationship between maximum strength in squat and 5-yard, 10-yard, and 40-yard sprint in footballers, where they found a statistically significant correlation between 1RM and sprint over 10 yards and 40 yards.

Compared to the multi-joint half squat, the aim of our study was to find out whether there is a relationship between the isokinetic strength of the knee flexors or extensors and the 10m or 30m running performance of elite football players in the Czech Republic. Muscle strength tested by an isokinetic dynamometer is one of the most frequently used methods for identifying the strength of the knee extensor (KE) and flexor (KF) among adult footballers. (Malý et al., 2013). From the aspect of injury risk, testing by an isokinetic dynamometer is more suitable than 1RM testing when performing squats, which are considered safe, but only for athletes without injury and with sufficient experience of strength training. The isokinetic testing of knee flexors and extensors is advantageous when compared to the isotonic in terms of obtaining information about the H/Q ratio, which is a major factor in the prevention of knee injuries. (Hughes & Watkins, 2006). Isokinetic testing brings unique possibilities of diagnosing muscle strength. Thanks to the possibility of regulating the speed of movement, this leads to the maximum tension by running of the whole ROM. Isokinetic strength measured on a dynamo-meter is sensitive to changes in strength caused by training strength in football (Brown, 2000). The test results show the relationship between the speed, strength and performance at various speeds (Štolfa, 2012). In comparison with regular tests, isokinetic measurements are more objective, they are more reliable and standardized (Dwir, 2004, Heyward, 2006, Vařeka et. al.,). Even Cerrah et al. (2011) confirms that isokinetic concentric strength is considered representative for determining the muscle strength of the lower extremities for football players.

In this study, we were interested whether it is possible to predict the speed ability of athletes based on the isokinetic testing of strength given a concentric activity of the flexors and extensors of the knee joint.

The strength of the flexors of the knee joint influences the length of the step, the stability of the joint during acceleration, when slowing down and when making changes in direction. The knee extensors are primarily involved in running, jumping and kicking the ball (Cerrah, 2011, Lehance et al., 2009.). All these activities depend on the level of the maximum strength of the neuromuscular system, particularity the lower extremities (Cometti et al., 2001).

The study of the authors Cotte & Chatard (2011) examined the relationship between PT (peak torque – isokinetic strength) and sprint times on 30m. A statistically significant relationship was found only between knee extensor strength during highly tested angular velocity and in the sprint on 30m. Malina et al. (2005) state that many physical activities performed in football generate power at high angular velocities. Cotte & Chatard (2011) explain that the knee flexors are activated eccentrically in order to prevent flexion of the hip joint and extension of the knee before contact with the pad and at the start of the supporting phase. In the course of the following phase combined contraction with extensors and stabilisation of the knee joint occur. These biomechanical relations explain why there is a relation between the isokinetic strength of knee extensors and speed of movement more than in the case of knee flexors. The main role of flexors is to protect the knee joint from injury. Croisier, Réveillon et al. (2003) state that an H/Q ratio of less than 0.6 may constitute to a significant risk indicator for a leg injury, such as injuries to the hamstrings or anterior cruciate ligament. Strengthening and increasing the H/Q ratio may prevent an increased risk of injury to the hamstrings and anterior cruciate ligament. However, the authors note that isokinetic testing does not need to completely correspond to the sprint as a result of the insufficient stretch-shortening cycle (SSC). (Cronin & Hansen, 2005).

Also Mero et al. (1992) point out to relationship between PT and sprint running times mainly on 20m and 30m and the lack of a relationship between PT and 10m sprint times. In contrast, the study of Oczkar (2003) points to a significant relationship between the isokinetic strength of the knee extensor and sprint over 10m.

The aim of the study is to determine the relationship between the isokinetic strength of flexors, extensors, their ratio H/Q, and sprint times on 10m and 30m.

Methodology

The strength of knee flexors and extensors (dominant limb) was tested by an isokinetic dynamometer at angular velocities of 60 and 240°.s^{-1} on fourteen football players (excluding goalkeepers) of the highest Czech league at the age of 23.2 (SD 5.3), body height of 182.8 cm (SD 4.2) and body weight of 76.6 kg (SD 5.2). Apart from the strength parameters, the hamstrings-to-quadriceps strength ratio was calculated from the test results. Another tested parameter was the 10m and 30m sprint running performance.

The diagnostics of the strength abilities of the lower extremities was realized unilaterally by means of the Humac Norm CSMI (Stughton, MA, USA), focusing on the unilateral testing of the concentric activity of the extensors and the flexors of the knee joint for the dominating extremity. The testing took place in the isokinetic regime at a range of 90°, using an angle speed of 60/ s-1 and 240°/.s-1. The test set was made up of 14 football players, who play in the top Czech league, age: 23.2 (SD 5.3), body height: 182.8 cm (SD 4.2) and body weight: 76.6 kg (SD 5.2). Prior to the diagnostics determined for generating data, 6 sub-maximum attempts were conducted with an increasing strength determined for warming-up the muscles. After a 30 second break, there were 5 maximum attempts for generating data. There was a 180 second break between the angle speed. The result of the measuring was the value of the peak torgue. (PT). Another tested parameter was the 10m and 30m sprint running performance. Players ran two times, rest interval was 3 min.

Processing and evaluation of the data

The verification of the hypotheses was carried out by the following statistical methods:

Tests of normality according to Lillieforse (Kolmogorov-Smirnov's test), which does not reject the normality of the data resolution; Pearson correlation coefficient.

Results

A significant correlation ($p<0.05$) between the isokinetic strength of knee flexors and extensors at an angular velocity of 60°.s^{-1} and 10m and 30m running performance was not detected. The relationship between the strength of knee extensors and 10m run as well as between the strength of flexors and 10m and 30m runs at the 240°.s^{-1} angular velocity was not detected. A statistically significant correlation was identified between the strength of knee extensors (240°.s^{-1}) and the 30m running performance ($r = -.0594$), $p = 0.025$. No relationship between the H/Q ratio and the 10m and 30m running performance was ascertained. The results of the tests between the isokinetic strength of knee flexors and extensors at an angular velocity of 60 and 240°.s^{-1} angular velocity and 10m and 30m running performance are stated in Tab. 1, 2, and Fig. 1.

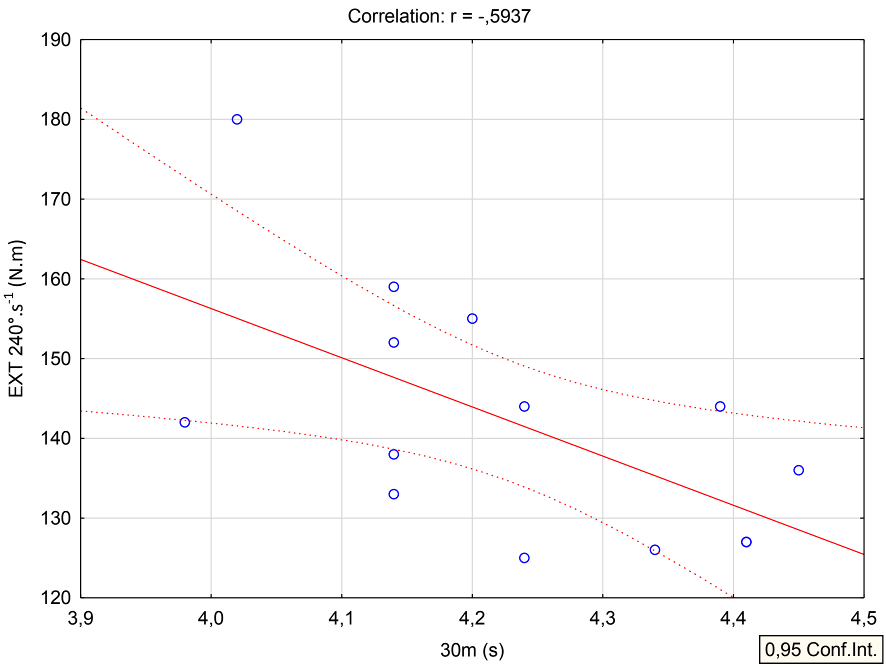
Table 1. The results of sprint time (10m and 30m running) and PT (peak torques) of knee flexors and extensors at an angular velocity of 60 and 240°.s-.

ID	AGE (years)	HEIGHT (cm)	WEIGHT (kg)	Lat.	10 m (s)	30 m (s)	E 60 PT (N.m)	F 60 PT (N.m)	H/Q R60	E 240 PT (N.m)	F 240 PT (N.m)	H/QR240
P1	20	186	72,3	R	1,74	4,24	222	117	0,52	125	95	0,76
P2	20	184	74	L	1,73	4,14	197	117	0,59	138	75	0,54
P3	22	181	72,5	R	1,68	3,98	226	157	0,69	142	103	0,72
P4	20	185	76	R	1,67	4,02	266	142	0,54	180	96	0,53
P5	18	185	81	R	1,72	4,24	202	126	0,62	144	87	0,60
P6	21	178	69	R	1,77	4,41	226	161	0,71	127	104	0,82
P7	23	184	77	R	1,76	4,14	237	152	0,64	152	106	0,70
P8	28	180	72,2	R	1,78	4,34	221	125	0,56	126	77	0,61
P9	36	181	80	R	1,84	4,45	213	133	0,62	136	88	0,65
P10	30	190	88,7	R	1,74	4,14	247	140	0,57	159	91	0,57
P11	28	182	88,2	R	1,85	4,41	239	130	0,55	127	71	0,55
P12	18	188	79	L	1,72	4,20	218	122	0,56	155	108	0,70
P13	19	182	75	R	1,82	4,39	213	140	0,66	144	85	0,59
P14	22	173,5	74	L	1,70	4,14	237	144	0,61	133	91	0,68

Lat. - laterality, E – knee extensors, F – knee flexors, 60, 240 – 60 $°.s^{-1}$ and $240°.s^{-1}$ angular velocity, H/Q R – hamstring/quadriceps ratio, PT – peak torque

Table 2. Correlation between PT (peak torques) of knee flexors and extensors at an angular velocity of 60 and $240°.s^{-1}$ and sprint times at 10m and 30m.

Variable	Correlations (data) Marked correlations are significant at p < ,05000 N=14 (Casewise deletion of missing data)					
	E 60 PT	F 60 PT	H/Q R60 PT	E 240 PT	F 240 PT	H/QR240 PT
10m	-,2419	-,1317	-,0538	-,4910	-,4770	-,0977
	p=,405	p=,653	p=,855	p=,075	p=,085	p=,740
30m	-,3628	-,1806	-,0908	-,5937	-,3908	-,0895
	p=,202	p=,537	p=,758	p=,025	p=,167	p=,761



Discussion

The results obtained by the authors of this study do not correspond to the results of similar studies that diagnosed the relationship between the maximum strength generated in the half squat exercise and the 10m and 30m running speeds. Isokinetic testing belongs to the testing category of exercises in open kinematic muscle chain, which is defined as the possibility to change the position of a segment without movement of positions of other segments. Exercise in the closed kinematic muscle chain, where a change in one segment is possible only with a change of position in other joints (for example squat), much better corresponds to the performance of athletes, and the results of many studies correspond to the statistically significant relationship between tests performed in a closed kinematic chain and performance of athletes. Biomechanical analysis (Jonhagen, 1996) also points to the main activation of knee extensors and primarily the gluteus maximus (knee extensor) in a sprint using EMG, in a manner similar to a squat and also technique and neuromuscular factors which impact performance in the sprint, also play a role.

The findings of Dowson et al (1998) given that times between the isokinetic muscle strength and the sprint performance at a range of 0 – 15 m (during the acceleration phase) improve, taking into consideration the length of the extremity and the body weight. Therefore to present the results, it is also possible to use the relative values related to kg of weight (Cometti et al., 2001; Kellis et al., 2001; Malý et al., 2010) in future studies.

It is also possible to take into consideration that the isokinetic dynamometry may also offer other parameters, such as for example, average work (AW), the angle, in which the highest performance (A) is achieved or the time necessary for achieving the maximum moment of strength (Tmax).

Conclusion

The maximum isokinetic strength of the knee flexors is not a determining factor for 10m and 30m running performance for football players. The velocity at which the flexor strength was tested was not decisive, although a significantly higher tendency to limit sprint performance was observed at $240°.s^{-1}$ when compared to the tendency at $60°.s^{-1}$. Concerning the knee extensors, the effect of isokinetic strength at $240°.s^{-1}$ on the 30m running performance was documented, indicating that the strength of the knee extensors positively affects selected velocities at higher speeds. Based on our results, we do not recommend using single-joint, isolated exercises for knee flexors and extensors to increase the pace of running acceleration speed of football players.

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CHANGE OF DIRECTION SPEED IMPROVES RAPIDLY COMPARED TO LINEAR SPEED AND EXPLOSIVE STRENGTH IN ADOLESCENT FOOTBALL PLAYERS

Hojka Vladimír[1]; Kokštejn Jakub[2]; Šťastný Petr[2]; Malý Tomáš[3]; Zahálka František[3]; Musálek Martin[4]
Czech Republic; Prague; Charles University; Faculty of Physical Education and Sport
[1]Track and Field Department; [2]Department of Sport Games; [3]Sport Research Center; [4]Department of Kinanthropology

Abstract

Purpose: The goal of the study was to establish dependence of change of direction speed (CODS), linear speed andexplosive strength on age in early adolescent football players.

Methods: Forty eight adolescent (178,5± 5.8 cm; 66.8 ± 7.3 kg; 14.90-16.74 years) participated in the study. All subjects underwent the protocol, which consisted of field (CODS and speed) and laboratory measurements (explosive and reactive strength). Group of speed and CODS test were performed on artificial lawn football field indoor. All test were measured by timing gates. Day later, the subjects were tested in the laboratory in explosive and reactive strength using force plate (Kistler, Winterthur, Switzerland). Pearson correlation, ANOVA and Cohen d were used to assess the relationship between CODS and the factors.

Results: The most significant relationship was found between age and CODS performance (r=0.11-0.51; d=0.31-1.20). Improvement in speed and strength was also observed, however the magnitude of change was not so high (trivial in linear speed; trivial-moderate in explosive strength indicators).

Conclusion: CODS improvement was rapid in comparison with linear speed and strength. It indicates improved motor control and execution in game specific movement. Further development would be achieved through development of strength capacities.

Key words: *CODS, linear speed, explosive strength, reactive strength*

Introduction

Agility, reactive agility and its subconcept change of direction speed (CODS) are in the interest of present research.Although allthree are nowadays considered as different movement qualities (Matlák, Tihanyi, & Rácz, 2016; Spiteri et al., 2015;

Young, Dawson, & Henry, 2015), there still remains an unexplored area, how they are related to fitness components or their interactions. We consider very important to emphasize also other subconcepts of CODS, which includes technical and anthropometrical aspects.

Generally accepted model of CODS performance (Young, James, & Montgomery, 2002) consists of sprinting speed and also muscle qualities, which may be expressed by maximum, explosive and reactive strength capacities. Previous studies dealt with the influence of linear speed and CODS (Delaney et al., 2015; Nimphius, Callaghan, Spiteri, & Lockie, 2016), the relation of explosive strength and CODS (Chaouachi et al., 2012; Sattler et al., 2015; Spiteri et al., 2015; Young, Miller, & Talpey, 2015). Conclusion of all mentioned studies was that CODS performance variance cannot be sufficiently explained by speed or explosive strength factors only. Recent studies showed moderate relation between reactive strength and CODS performance (Marković, Sekulić, & Marković, 2007; Sattler et al., 2015; Spiteri et al., 2014), however it still does not help to explain the complexity of CODS or even agility performance.

Age group is also very important factor in fitness training. Early adolescent age is associated with short time after termination of growth spurt. Due to hormonal changes, boys are entering window of opportunity to strength development due to possibility of hypertrophy. Also boys have to deal with rapid change in the anthropometry characteristics and change of neuromuscular qualities of their bodies. Linear speed should also improve fluently, as will explosive and reactive strength. As these are accepted subfactors of CODS fitness subconcept, we expect the CODS to improve proportionally to these subfactors with increasing age.

The goal of our study was to evaluate, whether the rate of change in CODS performance is proportional to the improvement in linear speed (acceleration and maximal) and explosive and reactive strength indicators in early adolescent age.

Methods

Forty eight football players (178.5 ± 5.8 cm; 66.8 ± 7.3 kg; 14.90-16.74 years) from teams playing first and second U17 and U16 Czech league participated in the study. Calendar age was calculated to the first day of measurement and was rounded on two decimals. Whole group was divided to two categories (U16 – 18 participants 14.90-15.99 years and U17 – 30 participants 16.00-16.90 years). All participants were active players being in regular training at least two years. None of them had been in injured or recovering from injury or illness. All participants and their coaches were informed about procedures connected with the study. Those who voluntarily agreed signed written consent. The project was approved by Ethic Committee of the Faculty.

The measurement was executed in first two days of training microcycle. Participants underwent a warm up session which consisted of 6 min jogging, dynamic stretching exercises, specific running drills and 3 non measured linear runs. The test of linear speed (40 meters with time gates placed on 5, 10, 20 and 40 meters) followed 3 minutes after finishing warm up. Participants placed their back foot on pressure sensor. The time triggered, when back foot left the ground. Maximal speed test results were obtained by subtraction of times on 40 and 20 meter gates. Each participant had two measured trials. Whole team was divided into group of 5-6 players, to ensure the appropriate recovery time between trials (2-4 minutes in dependence of test).

Following standardized test were used to measure CODS: 505 right and left, Illinois (Figure 1), Arrowhead (Figure 1), K test (Figure 2) and Hexagon (Figure 2). All test were measured by photocells (Brower Timing System, Draper, Utah, USA and Model R2, EG Medical, Brno, Czech Republic) with accuracy 0.01 s, Hexagon test was measured manually. Each participant performed one non-measured trial and then two measured trials.

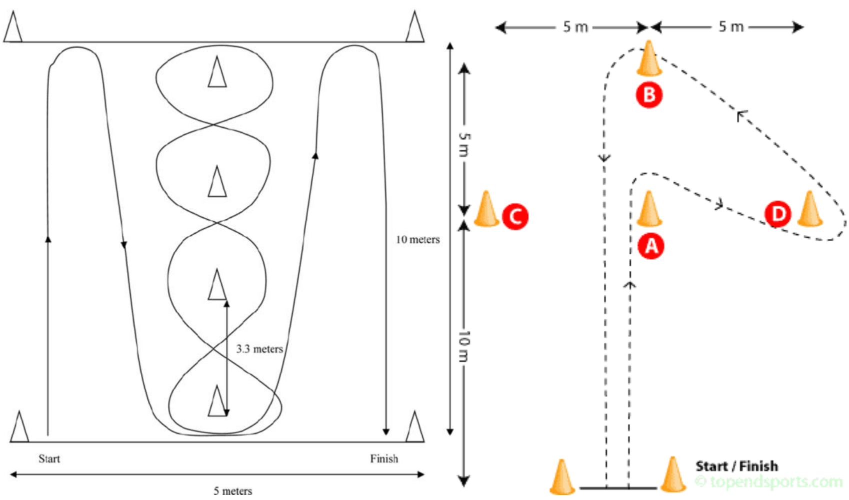

Figure 1. Illinois agility test (left) and Arrowhead agility test – right side (right picture).

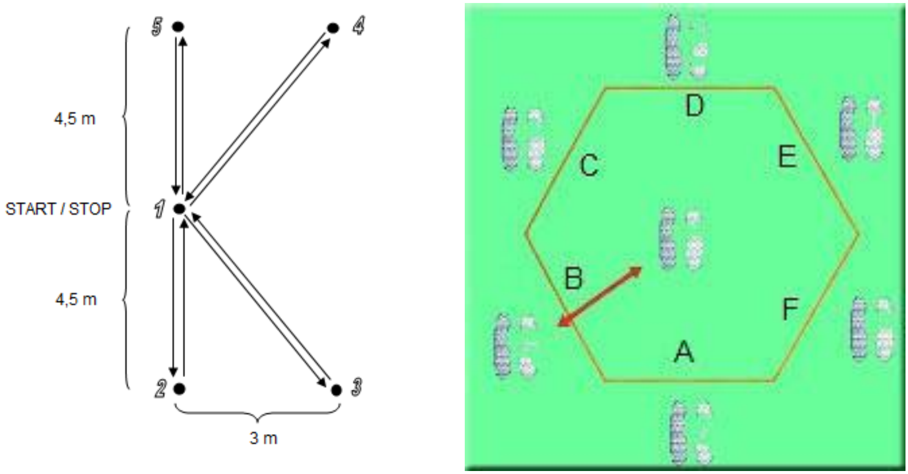

Figure 2. K-test (left) and Hexagon agility test (right).

Cones (40 cm) with contact switches on top were used and placed on locations 1-5 for K-test. Athlete should switch the cones in order 1-2-1-3-1-4-1-5-1. Athlete should jump 3 full revolutions in hexagon agility test.

The same warm up routine was performed on second testing day. Explosive and reactive strength test followed the warm up. Two force plates embedded in the floor (Kistler 6384, Winterthur, Switzerland) measured the ground reaction force. Countermovement jumps (CMJ) with free arms was measured in two trials, consisting of four attempts in each trial. Jump height (from force impulse and from flight time), relative peak force, peak velocity and relative peak power were calculated from the force plate data.

Participants performed 5 hops with free arms to evaluate their reactive strength level. Jump height, ground contact time, reactivity index (ratio of flight time and preceding ground contact time) and reactive strength index (ratio of jump height and preceding ground contact time) were taken as the reactive strength indicators.

Pearson correlation was used to determine relationship between age and measured fitness indicator. ANOVA was used to evaluate the statistical significance of correlation. Cohen d was the marker of effect size of the age group and fitness indicator.

Results

The results achieved in CODS test are presented in Table 1. Significant correlation was found between CODS and age, in Illinois test, Arrowhead (right and left) and Hexagon test. The effect size value indicates extreme improvement in above mentioned test.

Table 1. CODS test results (in seconds)

	Illinois	ArrowheadR	ArrowheadL	Arrowhead	K_test	Hexagon	R_505	L_505
U16	17.04±0.45	8.47± 0.18	8.46±0.15	16.93±0.29	11.17±0.27	10.76±0.65	2.49±0.10	2.49±0.11
U17	16.52±0.50	8.15±0.27	8.10±0.28	16.26±0.53	11.06±0.37	10.30±0.95	2.42±0.10	2.41±0.09
r	-.329*	-.456**	-.506**	-.501**	-0.188	-.323*	-0.105	-0.185
p	0.023	0.001	<0.001	<0.001	0.201	0.025	0.478	0.208
d	0.96	1.10	1.21	1.20	0.31	0.53	0.64	0.75

r – Pearson correlation; p = p-value; d = Cohen d; * significant at 0.05; **significant at 0.01

No significant relationship was found between the age and linear speed. The improvement was trivial or small as is displayed in Table 2.

Table 2. Linear speed tests results (in seconds)

	AR_5	AR_10	AR_20	AR_40	MR_20
U16	1.14±0.05	1.90±0.07	3.22±0.10	5.64±0.21	2.43±0.14
U17	1.12±0.07	1.89±0.10	3.19±0.13	5.63±0.21	2.44±0.11
r	-0.162	-0.092	-0.126	-0.098	-0.05
p-value	0.272	0.532	0.395	0.507	0.735
Cohen d	0.37	0.16	0.19	0.05	0.10

The results of explosive strength test are presented in Table 3. No significant correlation was found between age and indicator of explosive strength. However, small effect size was present in peak velocity and peak power.

Table 3. Results of countermovement jumps with free arms

	CMJ heigth impulse [cm]	CMJ height flight [cm]	CMJ peak force [N/kg]	CMJ peak velocity [m/s]	CMJ peak power [W/kg]
U16	36.7 ± 4.3	39.3 ± 4.1	26.3 ± 3.3	2.84 ± 0.14	58.2 ± 5.8
U17	37.7 ± 4.1	40.5 ± 4.6	27.9 ± 5.7	2.91 ± 0.17	60.8 ± 6.4
r	0.057	0.100	0.233	0.165	0.167
p-value	0.698	0.497	0.111	0.263	0.256
Cohen d	0.24	0.26	0.32	0.46	0.41

The reactive strength indicators did not show any correlation with age. However, jump height difference between groups pointed to moderate effect size.

Table 4. Reactive strength indicators results

	PLYO contact [ms]	PLYO RI	PLYO RSI	PLYO height [cm]
U16	210 ± 42	2.46 ± 0.43	1.53 ± 0.32	33.7 ± 3.3
U17	207 ± 33	2.48 ± 0.4	1.59 ± 0.33	35.9 ± 4.3
r	-0.089	0.06	0.084	-0.124
p-value	0.546	0.683	0.571	0.401
Cohen d	0.09	0.06	0.19	0.55

RI – reactivity index (flight time/contact time); RSI – reactive strength index (jump height/contact time)

Discussion

We did not find any remarkable changes in the level of linear speed, explosive or reactive strength in the early adolescent age group, however we proved an important relationship between age and CODS performance. The possible explanation of the phenomenon is due to improved motor control and coordination in game specific movements, which contain changes of movement direction.

The magnitude in improvement in physical fitness components is in agreement with other studies (García-Pinillos, Ruiz-Ariza, Navarro-Martínez, & Latorre-Román, 2014; Kramer, Huijgen, Elferink-Gemser, & Visscher, 2016). Especially no significant linear speed improvement was observed even in older adolescent (U18 group). However, the improvement in acceleration speed could be achieved by resistance training in same category (López-Segovia, Palao Andres, & González-Badillo, 2010). Similarly, the complex and contrast training seems to be a good strategy to further develop linear speed (Alves, Rebelo, Abrantes, & Sampaio, 2010). Our teams did not apply any form of resistance training, so if they do, it may lead to acceleration speed improvement.

Christou et al. (2006) proved, that football training leads to improvement of CODS abilities, which may be further increased by application of additional strength training. As the resistance training is applied, it leads to improvement in explosive strength indicators (such as jump height or peak power) (Alves et al., 2010; Christou et al., 2006). As our participant did not undergo any resistance training, they did not show difference in explosive strength parameters between age groups.

Plyometric training is another area which may lead to improvement in CODS, linear speed and also jumping performance (Söhnlein, Müller, & Stöggl, 2014; Váczi, Tollár, Meszler, Juhász, & Karsai, 2013). The advantage of plyometric was that its results proved very quickly (after 8, resp. 16 weeks). Although our groups did not apply specific plyometric training, they exhibited moderate difference in jump height between age groups. This difference may be explained by repetitive execution specific football movements (jumps, change of direction) in training and games.

Conclusion

Our study proved strong relationship between the age and CODS performance in early adolescents. However, there was no relationship between age and linear speed or jumping performance. The resistance and plyometric training might be suggested to further development of speed, CODS and jumping performance during later adolescent age.

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COMPARISON OF STRENGTH EXCERCISES ON BALANCE AIDS AND STABLE SURFACES

Jebavý Radim, Hojka Vladimír
Department Track and Field, Faculty of Physical Education and Sport, Charles University Praha, Czech Republic

Introduction

One of the factors, to which is given a lot of attention in sports practice, is the development of strength capabilities. At the present time, in addition to using traditional power tools such as dumbbels and fitness machines, balancing aids are being widely used as well. Compared to stable mats, balance aids have increased demands on stability, balance, coordination, reaction rate, strength and concentration. They can in terms of quality shift athlete´s training ahead, improving mainly the engagement of the deep stabilization system and indirectly contribute to higher sports performance (Jebavý & Zumr, 2014).

During each of our movements, the Deep Stabilization System is being activated (next reffered to as DSS) (Kolář & Lewit, 2005; Suchomel, 2006). DSS muscles are activated even during static load, for example: standing, sitting etc. It also accompanies every movement of the upper and lower limbs. Stabilization will never only involve one muscle, more so, the whole muscle chain is used due to the muscular connection. Spine stability as whole is important for perfect distribution of strenght between small deep and large muscle groups. If the core is unstable, it leads to unnecesary overload of the muscles, that are otherwise being used to perform the movement itself. All the more the correct activation of the DSS should be a crucial part of the weight room training (Čech & Tlapák, 2010). In today´sports practice, new training devices with the elements of preventive contra-action are being introduced thanks to the effort to increase efficiency. One of these is a stimulation of DSS by using balancing aids. In literature Behm et al. (2010), Wahl & Behm (2008), Čierná et al. (2010), Kyungmo et al. (2009); Anderson & Behm (2004), Elliot (1998), Süss et al. (2008), Čierna et al. (2010), Jebavý et al. (2012) etc. we come to the conclusion that exercising with balance aids can be more effective for the stimulation of DSS than exercising on a stable mat. In these publications different levels of athletes were tested, ranging from non-competitive to professionals, but also their sporting focus was different. In addition, these publications are unclear about what kinds of aids were effective for a given activity. Nor it is clearly established for which area of strength these exercises are optimized.

Key words: *deep stabilization system, balancing aids, stable surfaces, force intervention*

Objective

We assume that exercising with balancing aids has greater impact on the quality of DSS activation than similar exercises practiced on stable mat.

Research methods

Initially the first scenario was carried out to verify selected procedures, after that the comparison of intervention power programs with the use of balance aids and on stable mats

with impact on the quality activation of DSS was tested. In this experiment the impact of the DSS activation was evaluated. We evaluated the quality of DSS activation test in selected probes first in the pilot and then in the comperative study.

The test of the DSS quality activation was executed in cooperation with the Department of Physiology UK FTVS Praha. The test set consisted of men (amateur athletes) aged between 21 – 35 years with a focus on endurance sports without targeted strength training.

The activation of DSS was assessed for individual segments based on ordinal scale 1–5. Initially seven tests for the measurment of the quality activations of DSS were choosen as indicators. We first implemented the test as a pilot study for probands meeting our selection criteria (n = 12). In subsequent comparative study we used six tests with the experimental (n = 12) and control group (n = 12). Experimental group (next EG) carried out all the exercises exclusively with the balancing aids and the control group's (next CG) intervention included similar exercises, but on stable pads only. In the study we used DSS tests by Kolář (2006): dorsal tests, full flexion test, extension test, belly press test, arch test, lateral arch test to the left (right). The quality activation od DSS was assessed in both parts of the research by the same physiotherapist via aspects and palpation before and after the intervention program. The physiotherapist was not familiar with the group that proband belongs to. Reliability and validity of these aspects and palpation are not described in the literature and it is essential to follow them exactly as described.

Description of the intervention

This was a study with an intragroup experimental factor. As an experimental factor we chose a specific interventional motion program for both groups. In the period of ten weeks that included 22 exercise units (2-3 units per week for the time period of 35-45 minutes), the focus was on the manifestation of the power endurance in the dynamic and static mode.

Power exercises were executed in lower intensity (the repetition rate was determined by metronome in the rage of 2 to 4 seconds per repetition) and lower resistences (up to 40 % of the maximum force) and the number of repetitions ranged from 10-30 in static durations 15-30 seconds. The exercises were similar in both groups, evenly focused on core, lower and upper limbs. Each segment included around 1/3 of all exercises used. Exercise units included various modifications of strength exercises such as planks, plank, sit ups, squats, lunges, presses, push-ups, pull-ups that were precisly given. Instructions and guidence were overlooked by physiotherapist and trained trainer. EG group's exercises were performed on balancing aids and hanging systems (balancing hemispheres, air pads, suspension ropes, large and small ropes) and in CG's exercises were performed on stable pads (bench, floor, boxes, inclined plane, rails and rods).

Pilot study focused on the activation quality of DSS

The aim of the pilot study was to verify the effectivness of choosen exercises on the balancing aids focused on endurance power in dynamic and static regime on the quality of DSS engagement. The results of the pilot study showed, that the intervention power program with the use of the balancing aids had a positive effect on the quality of DSS activation. The experiment proved us the suitability of using chosen methods to compare the group exercising on the stable pads with only minimum adjustments.

Comparative study focused on the activation quality of DSS

Based on the conclusions of the the pilot study that was focused on the activation quality of DSS we conducted similar research on the comparison of intervention programs with the use of balance aids and stable pads. The goal of this study was to compare the effectivness of power exercises in dynamic and static regime on balancing and stable pads with the impact on the quality activation of DSS. This was a study with one intragroup (pre-test and post-test) and one intergroup (stable and non-stable surfaces) experimental factor. Methods of descriptive statistics (median, mean, standard deviations, percentiles) were used to characterize the set and describe the level of dependent variables. Qualitative differences of activity and insufficiency were assesed by five degrees on ordinal scale as done in the pilot study. The clinical significance of the difference between pre-test and post-test was assesed based on the 25th, 50th and 75th percentile distribution. A one step shift was considered significant. To assess the statistical significance of the difference between pre-test and post-test, Wilcox's paired test was used. Intergroup comparisons were assessed prior to intervention and after Mann-Whitney's test. Significant differences were considered at significance level $p < 0.05$.

Results

No significant differences between the groups at the level of activation of DSS ($p > 0.05$) were found prior to the intervention or after the intervention. However, both programs had a statistically significant improvement in DSS activation in all monitored variables (Figure 1). A clinically significant shift in median values occurred in the group on unstable surfaces in the extension test, the abdominal press and the arch. For the group practicing on stable surfaces, there was a clinically significant shift only in the extension test. It is interesting to evaluate the shift of 75 percentile values (worse DSS level). When exercising on stable surfaces, clinical improvement only occurred in the diaphrame test, while on unstable surfaces, improvement was observed for all tests except for the diaphrame test. At 25 percentile values (better DSS level) there was no significant shift in both groups.

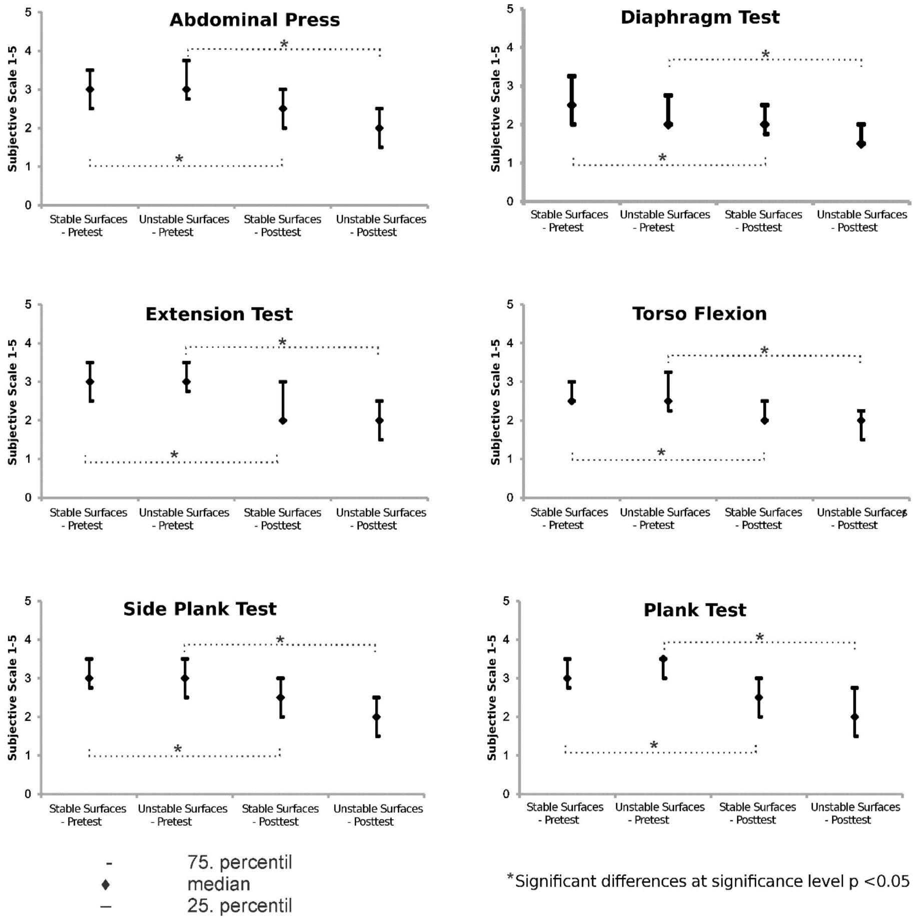

Figure 1. Assessment of the quality of DSS activation before and after the power program on stable and unstable surfaces

Discussion about comparative study focusing on the quality of DSS activation

The study showed positive influence of both power intervention programs on the quality of DSS activation in monitored individuals. EG had a very similar impact on the quality of DSS activation as in a pilot study. Similar exercises with the use of balance aids to aid the function of DSS with the same results that were used in our experiment are described in literature (Arosoki et al., 2001; Bačová et al., 2015; Pešán et al., 2015; Žiaková & Tanhäuserová, 2015; Kolář & Lewit, 2005; Kolář et al., 2009; Čepíková et al., 1999; Richardson, 1999; atd.). According to other different research (Yaggie & Campbell, 2006; Kyungmo et al., 2009) it is possible that balancing surfaces can accelerate and enhance the activation of DSS over the same exercise on stable mats. Our findings do not confirm this. The results of our measurement can be influenced by several other factors, such as selection of exercises, quality of performance, frequency of exercises, etc. Our battery of exercises in the intervention program was equally focused on all large segments (torso, lower limbs, upper limbs). It is very likely that if we would only focus on exercises in the core area, the results could be different.

The one question that still remains is optimal dosing in terms of frequency, difficulty of execution and length of the period for inclusion of strength exercises on the DSS, including level of training. Wahl & Behm (2008) report that exercises on unstable support surfaces are not a good incentive for professional athletes to increase strength as compared to them exercising on stable mats.

Another question that also remains, is finding optimal dosing in terms of the frequency and length of the period for the inclusion of strength exercises on DSS and the level of training. Authors Kolar & Lewit (2005), Behm et al. (2010) and Kyungmo et al. (2009) provide an explanation that superior activation of DSS in the spine area can be more stimulated on unstable support surfaces than on stable supports. This argument is particularly relevant for less trained (amateur) athletes, which corresponds to the groups surveyed. In the results, we also observed a clinically significant shift in the EG over KG in probes who entered the intervention with qualitatively lower values of DSS activation (75 percentile) than in probes with input values at 50 to 25 percentile. This suggests a faster adaptation to DSS activation, or overall core stability, using unstable surfaces for athletes who for various reasons have not been concerned with core activation before. However, we are aware that our chosen set of athletes is not a representative sample.

Conclusion

Based on our results, we can say that controlled exercises on balancing aids and stable surfaces appear to be effective for the development of DSS in an active population without a focus on strength training. Although the hypothesis has not been confirmed, but for a population with low quality of DSS activation, balancing exercises may be a higher training stimulus, and a faster adaptive response can be expected.The inclusion of strength exercises on balance aids and stable surfaces may be one of the most appropriate forms of compensatory means and DSS stimulation in the preparation of athletes of all performance levels. Also exercises using balancing aids are especially suited for the indisposed athletes who, for example, due to injuries have had for some time the core muscles inactive. These exercises are therefore recommended to be included in the reconditioning process.

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ANTHROPOMETRIC CHARACTERISTICS AND SOMATOTYPES OF MALE AND FEMALE ELITE THROWERS FROM THE CZECH REPUBLIC

Králová Tereza[1], Vanderka Marián[2], Cacek Jan[1], Hammerová Tereza[1]
[1]Masaryk University, Faculty of Sports Studies, Brno, Czech Republic
[2]Comenius University in Bratislava, Faculty of Physical Education and Sports, Bratislava, Slovakia

Abstract

Purpose: The purpose of this study was to find out the relationship between elite male and female throwers through the anthropometric characteristics and somatotype depending on each discipline. The sample consists of 28 elite female throwers and of 25 elite male throwers from the Czech Republic.

Methods: Anthropometric and somatotype variables were measured according to the Heath-Carter method, except the skinfolds, which were measured on the throwing hand-side. Body composition was measured by Bodystat QuadScan 4000. The statistical analysis of differences was tested by Kruskal-Wallis ANOVA, correlations were tested by the Spearman correlation coefficients ($p < 0.05$).

Results: The relationship between the waist circumference and competition performance showed stronger correlation ($r = - 0.82$) inside the men hammer throw. A positive correlation was found out among body height and performance inside the men javelin throw ($r = 0.90$). Other anthropometric parameters have no statistically significant correlation with performance. Results showed significant differences between female javelin and hammer throwers only, exactly in the body mass index ($p < 0.01$). Significant differences were found between body mass index and waist circumference between male javelin throwers and male shot putters ($p < 0.01$). The average somatotype of female throwers is for the hammer 5.1-5.7-0.7, for the discus 4.1-4.9.-1.8, for the shot 5.3-5.3-1.6, and for the javelin 3.7-4.5.-1.8 (average performance 58.13 ± 6.89 m). The average somatotype of male throwers is for the hammer 4.5-7.3-1.1, for the discus 3.5-6.8-1.3, for the shot 6.3-8.4-0.1 with turn technique (average performance 21.41 ± 0.68 m) and for the javelin 3.1-6-1.9 (average performance 74.95 ± 8.93 m).

Conclusion: The result of this study indicates the relationship between anthropometrics characteristics and performance in the men hammer and javelin throwers. The results show apparent similarities in the somatotype of the group of shot putters, hammer, and discus throwers compared to javelin throwers in both sexes. The anthropometrics measures and somatotype are an important factor in the

correct determining of throwing talents in these disciplines. These measures can be useful for later comparisons of anthropometric characteristics and somatotype in a long-term context.

Key words**:** *javelin throw, hammer throw, shot put, discus throw, anthropometric, somatotype, male, female, track and field*

Introduction

Athletics performance is traditionally linked with physical abilities and the technical skills. The main aim is finding talents and helping them make the most of their genetic predisposition. Coaches should correctly estimate proper discipline for the children and adolescents, especially in track and field disciplines. A number of studies observed statistically significant differences in weight among males in track and field between sprinters and throwers as well as between middle and long distance runners and throwers (Solaja, Milankov, Pejakovic, & Stokic, 2017). Male and female throwers had statistically higher BMI (= body mass index) than runners, jumpers and decathlon athletes (Solaja, Milankov, Pejakovic & Stokic, 2017). Taken together, the results of the above studies imply that we can find out if a child or adolescent has a predisposition for throwing or not in comparisons to other disciplines.

At the age of adolescence, it should be determined on which throwing discipline focused on. From the throwing groups are the javelinists usually clearly defined and the others are divided into two groups: training the hammer exceptionally with the shot put and traditionally the group which trains discus and shot put together. There are no recommendations for dividing the talents into proper throwing groups, the coaches base their choices on experience. There are not many relevant studies examining the somatic and anthropometrics characteristics between throwing disciplines. Most of the studies attempted to describe the differences in variables such as body weight, body height, body mass index, percentage of the body fat (= PBF), skinfolds. Junior shot putters achieved higher values (PBF, BMI, skinfold thicknesses) than the javelin throwers (Raschka, Vöth, & Kuczera, 2015). However, in various studies, the sum of skinfolds does not always include the same individual skinfolds or the same number of skinfolds (Knechtle, Stiefel, Rosemann, Rüst & Zingg, 2015; Legaz-Arrese & Serrano-Ostariz, 2005; Vucetić, Matković, & Sentija, 2008). In the literature, we can find less information about specific and proper somatotypes for throwers. Shot putters achieved a mean somatotype of 2.9-5.6-1.1 and the javelin throwers of 2.1-4.9-1.8 and there is still a development potential for the mesomorphic component (Raschka, Vöth, & Kuczera, 2015). In the Czech Republic, a somatotype of male shot putters and hammer throwers was measured by Štěpnička in 1977 only. There are no studies examining the anthropometric characteristics and somatotype of female and male throwers in each discipline.

Many authors (Orkwiszewska, 2007; Raschka, Vöth, & Kuczera, 2015; Singh, Singh, & Singh, 2011; Thorland, Johnson, Fagot, Tharp, & Hammer, 1981) studied the impact of somatic and morphologic characteristics on their athlete´s performance and concluded that the proper somatotype determines performance in throwing events. However, the performance depends on variations as well as on the training process and psychical conditions. One study concluded that the junior shot putters had the body height significantly positively related to performance (Raschka, Vöth, & Kuczera, 2015). There is also another main aim for other researchers to answer, and that is if the morphological characteristics, such as skinfold thickness, PBF, limb girth and length, body weight, body height, and body mass index (BMI), have an impact on athletic performance or not.

Methods

Participants

The sample consists of 28 elite female throwers and 25 elite male throwers from the Czech Republic, members of the national team and is grouped by the sex and discipline on female hammer throwers (n = 8), discus throwers (n = 8), shot putters (n = 7) and javelinists (n = 5) and male hammer throwers (n = 7), discus throwers (n = 8), shot putters (n = 5) and javelinists (n = 5). One of the inclusion criteria was at last two years of active competition at national and international levels. Each thrower was identified and analyzed from anthropometric measures and bioelectrical impedance analysis. All participants were informed about testing procedures and provided their written informed consent to participate in this study according to the research Ethics Committee. All participants entered the study voluntarily.

Procedures

The Carter and Heath method (Carter & Heath, 1990) was used to measure all anthropometric variables. According to this method, the right side of the body was used for right-handed throwers. For left-handed throwers, the left side of the body was used considering the relevance of the dominance of the body half, only 2 throwers (female) were left-handed. Each thrower´s body weight and body height were measured to the nearest 0.1 kg and 0.1 cm, respectively. Standard biceps, triceps, subscapular, supraspinale and medial calf skinfolds were taken to the nearest 0.5 mm using a Harpenden skinfold caliper according to the official guidelines. The epicondylar breadth of the humerus and femur was measured to the nearest 0.1 mm using a bone caliper with flexed arm (90°) and leg (90°). Segmental girths were taken to the nearest mm for the mid-upper arm in flexed arm to 45° in the elbow joint with maximum muscles contracted and for the mid-upper arm in flexed arm to 90° in the elbow joint with muscles relaxed. Waist circumference was also taken to the nearest 1 mm by stainless steel tape measure. The body height was measured using portable stadiometer Tanita accurate to 1 mm and the body weight was checked by digital Tanita scale accurate to 1 g. Using the Bodystat QuadScan 4000 the body composition was measured at PBF.

The measurements were conducted in the morning hours. The instruments were standard, and their accuracy was checked and calibration performed before each measurement and the same person measured all anthropometric features, thus reducing the possibility of measurement errors. Each anthropometric estimate was taken twice. If the difference between the two skinfold measurements was >10 %, a third measurement was taken and the mean of the two closest value was recorded for the further analysis. The Carter and Heath (1990) methods were used to rate the somatotype components (endomorph, mesomorph, ectomorph) of each participant. The mentioned performance of the throwers refers to the nearest competition to our measuring.

Statistics

All quantitative variables were summarized by means and standard deviations and were used to evaluate the assumption of normality. The statistical analysis of differences was tested by Kruskal-Wallis ANOVA, correlations were tested by the Spearman correlation coefficients and the analysis was tested at the $\alpha = 0.05$ probability level. All statistical analyses were carried out in STATISTICA 12.

Results

Table 1 represents various physical parameters and anthropometric measurements of the female throwers across the discipline. Results show significant differences between female javelin and hammer throwers only, exactly in the body mass index ($p < 0.05$).

Table 1. Characteristics of the female throwers

Parameter (mean + SD)	WOMEN Hammer throwers (n = 8)	WOMEN Discus throwers (n = 7)	WOMEN Shot putters (n = 7)	WOMEN Javelin throwers (n = 5)
Height (cm)	173,28 ± 7,85	180,85 ± 6,92	179,95 ± 6,76	173,64 ± 6,64
Weight (kg)	83,91 ± 11,13	83,78 ± 13,15	82,20 ± 5,70	73,38 ± 7,25
BMI (kg/m2)	27,83 ± 1,37***	25,50 ± 2,62	25,42 ± 1,16	24,42 ± 0,80***
Waist circumference (cm)	92,94 ± 7,91	91,50 ± 8,38	90,34 ± 4,59	85,4 ± 4,34
PBF (%)	22,99 ± 4,11	19,41 ± 5,89	18,94 ± 3,70	16,48 ± 3,66
LBM (%)	77,11 ± 4,00	80,69 ± 5,79	81,08 ± 3,74	83,52 ± 3,65
Performance	**60,46 ± 6,86***	48,75 ± 7,25	14,72 ± 1,25	**58,13 ± 6,89****

*with Czech record holder, ** with world record holder, *** p<0.05

Table 2 represents various physical parameters and anthropometric measurements of the male throwers across the discipline. Significant differences have been found between body mass index and waist circumference between male javelin throwers and male shot putters ($p < 0.05$).

Table 2. Characteristics of the male throwers

Parameter (mean + SD)	MEN Hammer thrower (n = 7)	MEN Discus thrower (n = 8)	MEN Shot putter (n = 6)	MEN Javelin thrower (n = 5)
Height (cm)	188,57 ± 7,69	193,81 ± 5,58	192,64 ± 5,82	188,94 ± 9,01
Weight (kg)	104,16 ± 8,62	115,31 ± 10,57	127,64 ± 8,77	93,54 ± 8,64
BMI (kg/m2)	29,34 ± 2,54	30,73 ± 3,19	34,44 ± 2,61***	26,18 ± 1,67***
Waist circumference (cm)	98,71 ± 7,80	100,50 ± 7,37	109,80 ± 5,26***	89,30 ± 6,42***
PBF (%)	10,61 ± 4,04	12,98 ± 2,75	16,04 ± 2,53	10,34 ± 4,25
LBM (%)	89,46 ± 4,15	87,06 ± 2,77	83,98 ± 2,54	89,68 ± 4,26
Performance	59,84 ± 5,46	56,69 ± 4,18	**21,41 ± 0,68***	**74,95 ± 8,93****

*with man in WORLD TOP 5 in 2017, ** with the 5. and the 6. men in WOLRD TOP in 2017, *** p<0.05

There were no other significant differences between groups in male throwers, but we can see some differences between body height and weight (Figure 1) in males. The javelinists weigh less than other throwers, whereas their body height has a larger margin. There is also shown that shot putters have bigger body weight together with relatively high body height.

The second goal of this study was to find if statistically significant correlations exist between the individual anthropometric characteristics and the competitive result in throwing. The results show stronger negative correlation ($r = -0.82$, $p < 0.05$) inside the men hammer throw between the waist circumference and competition performance. A strong positive correlation was found out in the body height and performance in the men javelin throw ($r = 0.90$, $p < 0.05$). But we must mention that we have a limited sample although two top world javelinists are included. Other anthropometric parameters have no statistically significant correlation with the performance.

The third goal was to find the average somatotype of each discipline in male and female throwing disciplines. The Figure 2 shows the somatotype of each discipline in different sex.

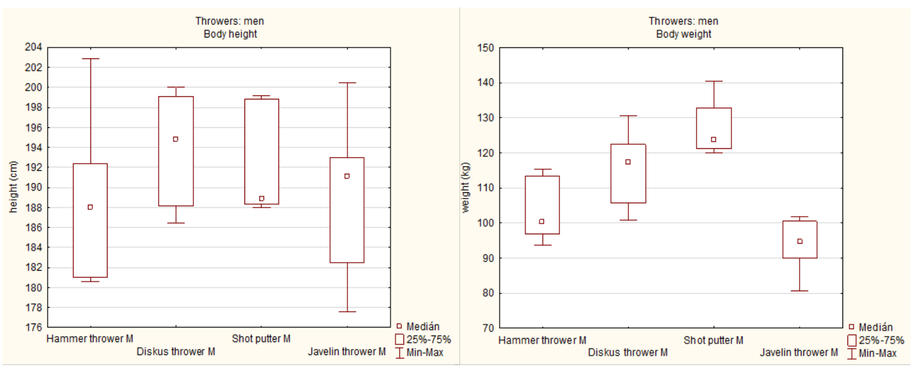

Figure 1. Male throwers: body height and weight

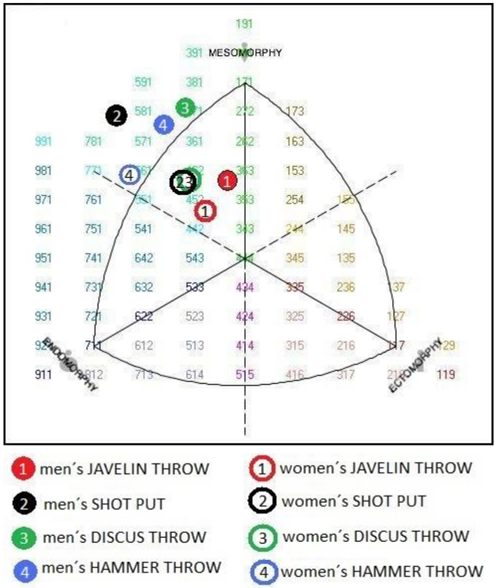

Figure 2. Average somatotypes of Czech elite throwers

The average somatotype of female throwers is for the hammer 5.1-5.7-0.7, for the discus 4.1-4.9.-1.8, for the shot 5.3-5.3-1.6, and for the javelin 3.7-4.5.-1.8. The average somatotype of male throwers is for the hammer 4.5-7.3-1.1, for the discus 3.5-6.8-1.3, for the shot 6.3-8.4-0.1 with turn technique and for the javelin 3.1-6-1.9. We can compare somatotypes of the Czech elite shot putters 6.3-8.4-0.1 with German male junior shot putters 2.9-5.6-1.1 and javelin throwers 2.1-4.9-1.8 (Raschka, Vöth, & Kuczera, 2015). These results show that elite junior German shot putters have less endomorphic and mesomorphic component that can change with age and training.

In the Czech Republic, Štěpnička (1977) conducted a research on somatotypes in athletes which included male shot putters and hammer throwers (Fig. No. 3). In comparison with our measuring, we concluded that shot putters in 1977 had similar somatotype as today with less endomorphic component, but hammer throwers have today bigger mesomorphic component that in 1997.

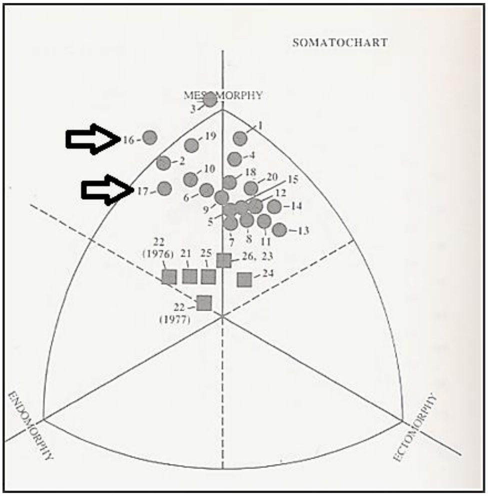

Figure 3. Czech somatotypes in 1977 (Štepnička, 1997) shot putters – 16; hammer throwers – 17

Discussion

Measured somatotypes of individual disciplines for both sexes indicate some differences and similarities for throwing disciplines. In the Czech Republic, most of the female shot putters compete also in discus throwing. That is the reason why our results show similarities in these disciplines for females. In assessing the somatotype of female javelinists, we consider that they accentuate the rate of mesomorphic components to be more like the male javelinists. Despite the corelationship between anthropometrics characteristics and performance in the men´s javelin throw, we should note the body height of the world record holder in the men´s javelin throw – Jan Železný, who measured in 186 cm body height and his body worked despite the small body height as an efficient slingshot (Ivancevic, T. T., Jovanovic, B., Jovanovic, S., Djukic, M., Djukic, N., & Lukman, A., 2010). We can consider that in the Czech Republic higher javelinists achieve better results than the smaller one. So there is a question why there is the big margin of the male javelinists body height, whereas they do not have a large variance in the body weight.

Conclusion

The result of this study indicates the relationship between anthropometrics characteristics and performance in the men hammer and javelin throwers. The results show apparent similarities in the somatotype of the group of shot putters, hammer, and discus throwers compared to javelin throwers in both sexes. The anthropometrics measures and somatotype are an important factor in the determining of throwing talents in these disciplines. These measures can be useful for later comparisons of anthropometric characteristics and somatotype in the long-term context.

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THE LEVEL OF ENDURANCE ABILITIES OF PRIMARY SCHOOL PUPILS IN BANSKÁ BYSTRICA

Kremnický Juraj, Čillík Ivan, Kollár Rastislav, Mandzáková Martina
Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica, Slovakia

Abstract

The aim of this article is the diagnosis, analysis and comparison of the level of endurance abilities of the pupils attending the 1st, 4th and 9th grade at primary schools in Banská Bystrica. Tested pupils were from all 11 public schools, which are in Banská Bystrica. Overall, we tested 492 pupils from the 1st grade, 433 pupils from the 4th grades and we tested 301 pupils from the 9th grade. We used te endurance shuttle run for testing endurance abilities of pupils. The results were compared according to age, gender and frequency of after-school sport activities. To verify the representativeness of files by sex, we used chi-square goodness of fit test. Representativeness was verified by default on 5 % level of significance ($\alpha = 0.05$). To verify the difference in performance of boys and girls, we used the t-test for independent Samples.

We found out statistically significant differences ($p < 0.05$) between boys and girls in the 4th and 9th grade as well as among groups according to somatic parameters and after-school activities. The number of excellent performances decreases with increasing age. Groups of boys and girls from the 1st, 4th and 9th grade of Banská Bystrica lagged behind in endurance abilities of boys and girls of the Slovak population.

***Key words**: Banská Bystrica, girls, boys, after-school sport activities, 20 m shuttle run test, 1st grade, 4th grade, 9th grade.*

Introduction

The young school-age phase is characterised by a high volume of aerobic activity which is manifested in different cardio games, exercises and sports activities. Exercise is a child's basic need and the condition for healthy body development. Exercise, cold water swimming and regular daily routines have a special importance for the maintenance of physical and aerobic activity. Belej (2001) states that the best activities for young-school-age children are cardio games, warm-up exercises, walking, running, jumping, climbing, throwing, drill, exercise to music, swimming, skating, skiing and hiking. It is easy to train endurance performance in this particular age. Aerobic activity has to be lively and interesting for children.

Endurance performance is improving in the ages between 11 and 15 years. The improvement of boys and girls is not equal though. As the years pass, the differences between girls and boys grow in favour of boys. When it comes to endurance performance, the differences between boys and girls are growing during puberty. While the aerobic capacity of boys continues to develop, the aerobic capacity of girls starts to stagnate. Boys at the ages between 12 and 15 years have a higher level of physical ability than girls with the same cardiac index.

Until the start of puberty, it is recommended to work solely on children's aerobic endurance, therefore tests used for the research of the endurance performance are based on the level of aerobic endurance. In general, endurance performance tests are a part of the tests used for the evaluation of physical capacity. The endurance performance is a part of standardized tests from the beginning of school age up until adulthood, for example EUROFIT (Council of Europe, 1988), UNIFIT (Měkota, Kovář et al., 1996; Měkota et al., 2002), FITNESSGRAM (Cooper Institute, 1999), ACTIVITYGRAM (Cooper Institute, 2004).

The aim of this paper is to diagnose, analyse and compare the level of endurance performance of the 1st, 4th, and 9th grade pupils at primary schools in Banská Bystrica.

Methods

Our research group consisted of pupils from all 11 schools in Banská Bystrica. From all the 1st grades 492 pupils were tested (252 boys, 240 girls). The decimal age of the boys' research group was 7.39 ± 0.43 years and the decimal age of the girls' research group was 7.24 ± 0.34 years. From all the 4th grades, 433 pupils were tested (220 boys and 213 girls). The decimal age of the boys' research group was 10.37 ± 0.44 years and the decimal age of the girls' research group was 10.21 ± 0.4 years. Finally, from all the 9th grades 301 pupils were tested (197 boys, 134 girls). The decimal age of the boys' research group was 14.88 ± 0.39 years and the decimal age of the girls' research group was 14.76 ± 0.39 years. When our research groups of boys and girls are compared with the research group of the Slovak population (PHA SR, 2013) they reach similar figures of body development (body height, body weight and BMI).

There was general warm up before the testing. In order to test the endurance performance of pupils the 20 m shuttle run test (20mSRT) of EUROFIT. The EUROFIT fitness test battery was selected in this study because it is probably the most extended, validated and standardized method for assessing children's physical fitness in Europe. The 20mSRT is a progressive CRF test where children and youth are asked to run laps back and forth between two parallel lines 20 m apart. An audio recording paces the participants beginning at a speed of 8.5 km/h and increasing by 0.5 km/h every consecutive minute. The performance is validated by the number of stages completed. Maximum performance was determined when the child could no longer maintain the pace or when the child decided to stop due to exhaustion Moravec, Kampmiller, Sedláček, et al. (2002).

We used a questionnaire to evaluate the involvement in after-school sport activities in all research groups. The after-school activity must be organized and led by sport coach or instructor minimum twice a week.

Pupils' results were compared according to their age, sex and their involvement in after-school sport activities.

We chose the following descriptive statistical characteristics – for measurements of central tendency we used the arithmetic mean (x) and for measures of variability the standard deviation (SD).

According to statistical figures, arithmetic average (x) and the level of variability – standard deviation (SD) a subject analysis was used to define the criteria and the range of the level of general physical capacity and we set our rating scale for this particular research group.

The scale chart stems from our data collection, the average value is calculated from the 20mSRT performances of the boys and girls in Banská Bystrica.

More than x + 2.5 SD - outstanding level
x + 1.5 SD to x + 2.5 SD - very good level
x + 0.5 SD to + 1.5 SD - above average level
x ± 0,5 SD - average level
x - 0.5 SD to x - 1.5 SD - below average level
x - 1.5 SD to x - 2.5 SD - low level
Less than x - 2.5 SD – unacceptable level

A level of endurance, more than x + 2.5 SD is a great result and a sign of a talented pupil. On the contrary, results worse than x − 1.5 SD and more are considered to be very weak and low level (unacceptable level) according to the monitored research group in Banská Bystrica.

Table 1. Rating scale of 20 m stages completed in 20mSRT research group in Banská Bystrica

	1st grade		**4th grade**		**9th grade**	
	BOYS stages (n)	**GIRLS stages (n)**	**BOYS stages (n)**	**GIRLS stages (n)**	**BOYS stages (n)**	**GIRLS stages (n)**
Outstanding level	≥ 51	≥ 46	≥ 81	≥ 64	≥ 111	≥ 68
Very good level	50 - 41	45 - 36	80 - 64	63 - 50	110 - 88	67 - 54
Above average level	40 - 28	35 - 25	63 - 46	49 - 37	87 - 66	53 - 41
Average level	27 - 16	24 - 15	45 - 29	36 - 23	65 - 43	40 - 27
Below average level	15 - 4	14 - 5	28 - 12	22 - 10	42 - 20	26 - 13
Low level	3 - 1	4 - 1	11 - 1	9 - 1	19 - 1	12 - 1
Unacceptable level	0	0	0	0	0	0

In order to verify the representativeness of the research group, Pearson's chi-squared test. The research groups of girls and boys were used (p-value in the 1st grade – 0.804, in the 4th grade – 0.136, in the 9th grade – 0.606). In order to verify the differences between the groups of boys and girls we used the t-test.

We used Independent-Samples T Test to determine the significance of differences between the research groups of boys and girls in all monitored parameters. The probability of a type I error (alpha) was set at 0.05 in all statistical analyses. Statistical analysis was performed through software IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences).

Results

Our research showed that the boys had better average levels of endurance running performance than girls in every age category (Tab. 2).

At the age of 7 years, the difference between the performances of boys and girls is small but it grows with age in favour of boys. A statistically significant difference was measured in favour of boys in the age category of 10 and 14 years. However 10-year-old boys delivered a better performance than 15-year-old girls. The performances for all ages in both boys and girls research groups were evaluated at average level.

Table 2. The number of 20 m stages completed in 20mSRT

	1st grade		4th grade		9th grade	
	BOYS stages (n)	**GIRLS stages (n)**	**BOYS stages (n)**	**GIRLS stages (n)**	**BOYS stages (n)**	**GIRLS stages (n)**
x	21.47	19.87	37.08	29.51	49.54	32.70
SD	11.79	10.20	17.28	13.46	21.49	13.10
Difference	1.60		7.57*		16.84*	

Explanatory notes: x – average; SD – standard deviation; * statistically significant difference ($p < 0.05$).

The comparison of endurance levels of the research groups of boys and girls from Banská Bystrica (2016) with the research group Slovakia (1993) showed that research groups from Banská Bystrica (2016) had a worse endurance performance in every age group (Tab. 3). The comparison of our research groups of boys and girls from eastern Slovakia (Turek, 1999; Ružbanská, & Turek, 2007) showed the opposite rate though.

Table 3. The comparison of average results in 20mSRT of our research groups of boys and girls with the results of previous researches

BOYS	**1st grade stages (n)**	**4th grade stages (n)**	**9th grade stages (n)**	**GIRLS**	**1st grade stages (n)**	**4th grade stages (n)**	**9th grade stages (n)**
Banská Bystrica (2016)	21.47	37.08	49.54	**Banská Bystrica (2016)**	19.87	29.51	32.70
Slovakia (1993)	31.70	43.56	60.52	**Slovakia (1993)**	27.31	39.97	37.48
Eastern Slovakia (1999)	20.80	31.87		**Eastern Slovakia (1999)**	18.91	23.37	
Eastern Slovakia (2007)	20.83	29.4		**Eastern Slovakia (2007)**	17.93	22.64	

When it comes to 20mSRT, the difference between boys who attend after-school sport activities and those who do not is statistically significant in all age categories (Tab. 4).

Furthermore, this difference grows gradually in favour of boys who attend after-school sport activities. In 7-year-old group the difference is 6.12 stages, in 10-year-old group it is 13.10 stages and in 15-year-old group the difference is 16.96 stages. The performances of all age groups who participated to after-school sport activities and 1st graders who did not participate to after-school sport activities were rated in average level. However 4th graders and 9th graders without after-school activities were rated in below average level.

Table 4. The comparison of performance in 20mSRT of boys not attending after-school sport activities with boys who attend after-school sport activities

BOYS	1st grade NA	1st grade A	4th grade NA	4th grade A	9th grade NA	9th grade A
	n = 93	n = 159	n = 54	n = 166	n = 92	n = 72
	stages (n)	stages (n)	stages (n)	stages (n)	stages (n)	stages (n)
x	17.61	23.73	27.20	40.30	42.03	58.99
SD	9.32	12.50	13.48	17.2	15.69	24.19
Difference	6.12**		13.10**		16.96**	

Explanatory notes: NA – not attending after-school sport activity; A – attending after-school sport activity; n – number of research groups; **Statistically significant difference ($p < 0.01$).

Looking at the endurance shuttle run, the difference between girls who attend after-school sport activities and those who do not is statistically significant at the age of 10 and at 14 years (Tab. 5).

The difference grows in favour of girls attending sports activities. In the 7-year-old group the difference is 1.3 stages, in the 10-year-old group it is 6.7 races and in the 14-year-old group the difference is 11.01 stages. The performances of all girls research groups were evaluated at average level. However the girls not attending after-school sport activities were rated at lower edge of average level.

Table 5. The comparison of performance in 20mSRT of girls not attending after-school sport activities with boys who attend after-school sport activities

GIRLS	1st grade NA	1st grade A	4th grade NA	4th grade A	9th grade NA	9th grade A
	n = 104	n = 136	n = 62	n = 151	n = 75	n = 62
	stages (n)	stages (n)	stages (n)	stages (n)	stages (n)	stages (n)
x	19.12	20.44	24.76	31.46**	27.70	38.71**
SD	10.42	10.03	10.50	14.11	9.24	14.56
Difference	1.32		6,70**		11.01**	

Explanatory notes: NA – not attending after-school sport activity; A – attending after-school sport activity; n – number of research groups; **Statistically significant difference (p <0.01).

The analysis of the results of 20mSRT according to the rating scale shows there were 13 performances in the 1st grade (7 boys and 6 girls) and 6 performances in 4th and 9th grade (2 boys and 4 girls) rated in the outstanding level.

Overall, there were 3 performances in the 1st grade (1 boy, 2 girls) 6 performances in the 4th grade (5 boys, 1 girl) and no performance in the 9th grade which was rated in low level of endurance abilities.

Discussion

Improving endurance performance and associated research are not very popular sport activities among children, but with the right motivation, they can perform beyond the boundaries of their expectations. During our research into endurance performance, we have met with a positive attitude from boys and girls in every age group.

Our results are similar to those of Kučera, Kolář, Dylevský, et al. (2011) which shows that from 5 years of age boys have a slightly higher level of VO2 max. Until the age of 12 those levels are just about the same. Our research proved that differences are already significant at the age of 10 though. They grow until the end of puberty, when this growth starts to slow down and approximately at the age of 14 it stops (Kučera, Kolář, Dylevský, et al., 2011).

Drabik (1989) found big differences between boys' and girls' endurance, which further continues to grow.

When our research group was compared to that from before 20 years the endurance was lower. This is considered to be a part of a secular trend. The biggest decline of endurance was measured in the group of 7-year-old children (32% boys, 27% girls).

Foreign authors claim a lower year-on-year decline of endurance. For example, Updyke and Willett (1989) state that the year-on-year decline of children's endurance is 1.1%. In Poland, the year-on-year decline of endurance of children (from the age of 7 to 19) was 0.7% (Przeweda, & Trzesniowski, 1996). Tomkinson et al. (2003) analysed the reasons of the decline of endurance performance in several countries. They compared the declining number of children who walk to school with the increasing number of children who go to school by car. Furthermore, they analysed how often children ride a bicycle annually. This number is declining.

Conclusion

Our results showed that boys have better running endurance in 4th and 9th grade (statistically significant at $p < 0.05$). In both boys' and girls' groups there has been high development of endurance during the young-school age.

In comparison with the research group Slovakia (1993) our research showed lower levels of endurance performance in every age group at statistically significant levels. In the group of 7-year-old children there was approximately a 1.5% year-on-year decline of endurance in comparison with group Slovakia (1993). On the contrary, our research groups of girls and boys are better than their peers from eastern Slovakia (Turek, 1999; Ružbarská, & Turek 2007). After-school sport activities have a positive influence on the difference of endurance performance between boys and girls. Our cross-sectional study indicates that differences exist in endurance between groups that do or do not participate in after-school physical activities. As the years pass the difference is getting bigger.

Acknowledgements

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PHYSICAL ACTIVITY AND SOCIOPATHOLOGICAL PHENOMENA AMONGST CHILDREN AT ELEMENTARY SCHOOL

Prukner Vítězslav
Faculty of Physical Culture, Palacký University Olomouc

Abstract

Purpose: The main objective of our contribution is to analyse the relationships between the level of physical activity and the occurrence of pathological phenomena (alcohol consumption, tobacco use and marijuana) among pupils at the 2nd level of elementary school.

Methods: The International Physical Activity Questionnaire (IPAQ) was used to collect data related to the diagnosis of physical activity frequency, which determines the intensity and duration of physical activity during the previous 7 days. For the purposes of this research, a short version of the IPAQ questionnaire was selected which contains a total of 7 questions.

For the collection of data related to the frequency of occurrence of selected adverse events, an international standardized ESPAD questionnaire was used within the framework of the European School Study on Alcohol and Other Drugs, from which selected questionnaire questions were compiled. The ESPAD International Project is the largest pan-European study on the use of addictive substances in adolescents. For the purpose of this research, 7 questions from this questionnaire were selected.

Results: In the results we bring analyses the students experience and frequency of smoking, drinking alcohol and smoking marijuana and analyses the relation between the occurrence of this phenomena and intensity of physical activity.

Conclusions: In the monitored children, we found a similar tendency to use selected addictive substances regardless of the frequency and intensity of the physical activity or sex.

Key words: *physical activity, alcohol, cigarettes, marihuana, sociopathological phenomena, IPAQ, ESPAD, children at elementary school*

Introduction

Experiments and drug abuse, including alcohol, nicotine and psycho-active substances, are still very current and increasing issue among the Czech children and youngsters. Not only does these drugs have harmful effect on the health and life style of individuals, it can also be the cause of further undesirable behaviour.

The alcohol introduces a serious risk for children and youngsters. It brings even bigger danger of development of serious health problems and alcohol poisoning due to the lower tolerance to alcohol amongst this age category. At the same time, the chance of developing an undesirable behaviour under the influence of alcohol is increasing (Nešpor, 2000).

Consumption of alcohol is connected to consumption of other psycho-active substances, most often with illegal drugs or tobacco smoking. Most clear connection was proved also with high-risk sexual behaviour (WHO, 2007). According to the results of ESPAD study from 2011, alcohol consumption amongst 16-year-old boys is connected most often with fights (23,4 %), worse job or school results (21,1 %), problems in relationships with parents (20,7 %) and accidents or injuries (both 19,3 %). Amongst 16-year-old girls the alcohol consumption is connected to problems in relationships with friends (27,7 %), with parents (21,7 %), worse results at school (19,2 %), sexual experience that the individual regretted the very next day (15 %) or sexual intercourse without protection (14,7 %). Majority of Czech children taste alcohol for the first time at the age of 13. At the age of 15 then majority of adolescents say that they consume alcohol regularly, at least once per month (Kalman, 2011, s. 80). According to the results of ESPAD study from 2011 97, 9 % of 16-year-old youngsters already have experience with alcohol. The most consumed alcohol is beer, then liquors and finally wine and so-called alcopops (Chomynová, Csémy et al., 2014).

Beginnings of smoking amongst children and youngsters can be related to the desire of imitating the adults or friends or desire to be part of their community (Hájek & Harmach, 2004). Not only is the smoking harmful to health of human and his surroundings, it can also lead to nicotine addiction since childhood and it can harmfully influence his life (e.g. decreasing of his physical condition and general degradation of physical activity). Development of nicotine addiction is most dangerous amongst youngsters. Results of HBSC study from 2010 shows that 90 % of smokers started to smoke before turning 18 (Kalman, 2011). Results of HBSC study from 2014 amongst selected states of central Europe shows that Czech pupils smoke more often compared to European averages. Majority of pupils say that experience with tobacco had at the age of 13-15 (HBSC, 2016). From the results of ESPAD study from 2011 we can say that more than one quarter of Czech asked pupils gained their first experience with smoking at the age of 11 and less. ESPAD study also shows that 75,2 % 16-year-old respondents have already smoked at least once. According to the Kastnerová (2008), in agreement with the results of ESPAD study, it is worldwide trend to smoke earlier and earlier.

Smoking of marijuana is the most widespread kind of illegal drug. In the Czech Republic the marijuana is the most used drug immediately after alcohol and tobacco.

Although its growing and distribution is illegal, it is not very difficult neither for Czech students at the 2nd level of elementary school to get to this drug. Equally as with alcohol, marijuana smoking is connected to other undesirable behaviour, such as consumption of other drugs and other social-pathological phenomena, e.g. criminal acts, dangerous sexual behaviour etc. (Kalman, 2011). Unlike alcohol and tobacco consumption, these substances cannot be bought at the free market and their selling is considered illegal. Regarding marijuana abuse, Czech children at the age of 15 strongly exceed the world average. At least 30 % of children at the age of 15 already had an experience with marijuana and 11 % of them use marijuana regularly at least once a month (HBSC, 2016). According to the results of ESPAD study from 2011, 42,3 % 16-year-old respondents used hemp substances at least once. Most common age of the first experience with hemp substance is 15 years (Chomynová, Csémy et al., 2014)

Children and youngsters are not just peripheral endangered part of population, statistic shows that drug abuse is most distinctive at the age from 15 to 19 (Kalina et al., 2003).

The importance of physical activity in prevention of undesirable phenomena amongst children and youngsters can be seen especially from the point of view of positive effects, which exercise has on human body and psyche and therefore it decreases the danger of occurrence of harmful behaviour. (Hájek & Harmach, 2004). In the elementary school the prevention through physical activity is realized especially via Physical Education (PE). Activities covered in PE curriculum at the 2nd level of elementary school are defined in MŠMT document in RVP for elementary education. Motivation to physical activity amongst adolescent was explored by Christiana et al. (2014). These authors found out that activities of young adolescents depend on what the others think and on perception of control. Degree of activity, predominantly outdoor and non-competitive, is largely connected with their inner motivation. Parents exerting pressure on adolescents has not big effect, on the other hand, their support is crucial. Adolescents that regularly take active part in physical activity and eat more fruit and vegetable compared to others with sedentary behaviour are not overweight so often, are more responsible in taking contraception and their marijuana and cocaine abuse is much lower (Pharr & Louhg, 2014). Study of Sebire et al. (2014) even shows that physical activity of parents has positive effect on the physical activity of their children. These authors think that level of physical activity is connected to self-efficacy ale self-evaluation that has influence on e.g. professional life. It was discovered that boys dedicate bigger amount of time to physical activity than girls regardless the race or ethnic group (Pharr & Louhg, 2014). Another important parameter that influence the level of physical activity amongst adolescents is socioeconomic status. The lower family socioeconomic status, the lower level of physical activity.

According to the Kudláček & Frömel research (2012), the age spectrum (15-18 years) is increasing for the level of physical activity, up to 17 years for the group of girls. The boys have seen a significant increase in 18-year-old boys.

Figure 1. Level of physical activity in individual age categories of girls (MET-min/ week). (Kudláček & Frömel, 2012, 58).

	15 years old (n=34)		**16 y.o. (n=72)**		**17 y.o. (n=53)**		**18 y.o. (n=57)**	
	Mdn	IQR	Mdn	IQR	Mdn	IQR	Mdn	IQR
Intensive PA	90	810	375	1530	540	1440	540	1260
Moderate int. PA	695	1650	928	140	1670	2145	770	1890
Walk	858	1122	1510	2013	2046	2478	1749	2079
General PA	2372	3691	3742	5080	4467	4614	3219	4837

Key: n – number, Mdn – median, IQR – interquartile range, PA – physical activity

Figure 2. Level of physical activity in individual age categories of boys (MET-min/ week). (Kudláček & Frömel, 2012, 60).

	15 years old (n=34)		**16 y.o. (n=72)**		**17 y.o. (n=53)**		**18 y.o. (n=57)**	
	Mdn	IQR	Mdn	IQR	Mdn	IQR	Mdn	IQR
Intensive PA	1440	1290	675	2205	960	2520	1935	3780
Moderate int. PA	1560	3060	1151	1945	1205	2180	2017	3015
Walk	1435	2343	1320	2227	1303	1947	1353	3168
General PA	5220	6365	4270	5351	4567	3530	6564	8735

Key: n – number, Mdn – median, IQR – interquartile range, PA – physical activity

Numerous studies proved existence of significant influence of physical activity on occurrence of undesirable social-pathological phenomena. Children and youngsters with low level of physical activity suffer psychological problems, depressions or anxiety more often. At the same time degree of participation on physical activities and sports can be connected to higher level of criminality, drug abuse or other illegal substances etc. (Merino, Briones, 2012).

The main objective of our contribution is to analyse the relationships between the level of physical activity and the occurrence of pathological phenomena (alcohol consumption, tobacco use and marijuana) among pupils at the 2nd level of elementary school.

Methods

For the purposes of this research, two questionnaires were used. For the collection of data related to the level of physical activity it was used an international standardized IPAQ (International Physical Activity Questionnaire) that investigates the intensity and duration of physical activity amongst respondents in the last 7 days.

This questionnaire was created to provide sophisticated instruments for international comparable investigation of facts concerning physical activity and it is publicly accessible to free use. For the purpose of our research the short version of the IPAQ was selected that contains 7 questions in total (longer and more detailed version contains 27 questions).

For the collection of data related to the frequency of occurrence of selected adverse events, an international standardized ESPAD questionnaire was used within the framework of the European School Study on Alcohol and Other Drugs, from which selected questionnaire questions were compiled. The ESPAD International Project is the largest pan-European study on the use of addictive substances in adolescents. For the purpose of this research, 7 questions from this questionnaire were selected. The involved states, with respect to ensuring the comparability of the results between countries, are obliged to follow united methodological procedure including unite questionnaire and procedure in data collection. ESPAD questionnaire contains 53 closed questions, for the purpose of our research 7 questions were selected.

Research group

For the purpose of our research the research group was comprised of 9th-grade pupils from elementary school aged 15-16. Boys and girls from Demlova Elementary School and Řezníčkova Elementary School in Olomouc participate in the research. After agreement with competent deputy of the school pupils from four classes were asked to participate in research. 110 pupils were addressed. Unfortunately, 8 questionnaires had to be eliminated because of the incorrect completion. Final number of respondents that analyses works with was 102 (50 boys and 52 girls).

Method of evaluation of IPAQ

Individual physical activity is put into the formula containing MET-min constant (average mean, score for individual kind of activities) that it determined in advance for every kind of physical activity. Individual formulas for calculation of PA level are introduced lower. Participants were divided by median into two groups: pupils with low PA intensity and pupils with high PA intensity (MET-min/week).

Calculation of low PA (walk): 3,3 MET x number of minutes of PA per day x number of days per week.

Calculation of moderate PA: 4 MET x number of minutes of PA per day x number of days per week.

Calculation of high PA: 6 MET x number of minutes of PA per day x number of days per week, when the PA was executed.

In both groups it was discovered a certain experience with selected addictive substances according to the results of ESPAD. Boys and girls were separated during the analyses. For each question, number of individual answers was evaluated, according to that the partial conclusions were deduced about occurrence and experience with individual adverse events amongst girls and boys and then amongst the whole research group. For statistical testing of the importance the chi-square method was used, the conditions of approximation were reserved for contingent chart. During the calculations we worked with level of significance $\alpha = 0,05$.

Results

Discovered results of amount and structure of intensity of PA brings graph 1. According to the graph comparing moderate numbers of MET-minutes among boys and girls we can say that boys show higher numbers in all categories, except for sitting. Boys reached the highest numbers in intensive PA, compared to girls where the highest moderate numbers were discovered in low PA.

Graph 1 Moderate numbers in MET-minutes per week

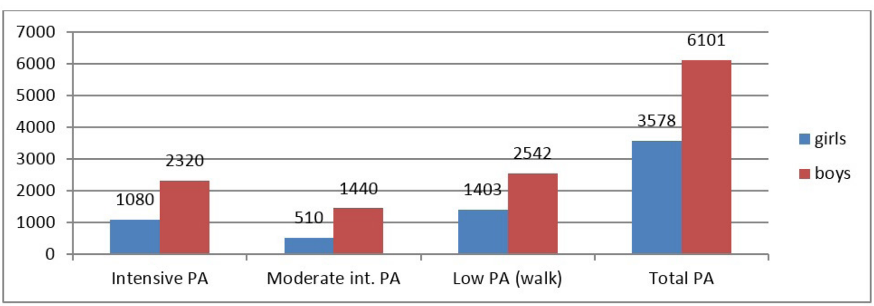

Figure 1. Moderate numbers in MET-minutes per week

Comparison of number of experience with individual addictive substances amongst pupils with lower and higher PA revealed that more frequent experience with addictive substances can be seen amongst respondents with lower PA.

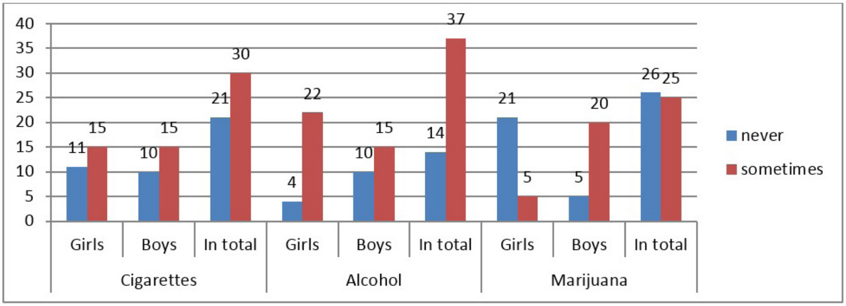

Figure 2. Experience with addictive substances amongst pupils with higher PA

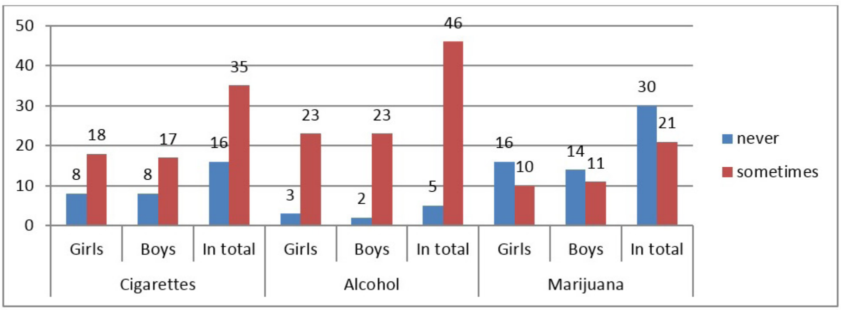

Figure 3. Experience with addictive substances amongst pupils with lower PA

Among boys and girls with higher amount of PA, 59 % say that they have at least one experience with smoking cigarettes, almost 73 % admitted experience with alcohol and 49 % admitted their experience with marijuana. 69 % of respondents with lower amount of PA have at least one experience with cigarettes, 90 % with alcohol and 41 % with marijuana. Regarding cigarettes and alcohol, pupils with lower amount of PA show higher amount of experience, as for the marijuana abuse, pupils with higher amount of PA have more experience.

Higher PA				Lower PA			
		never	sometimes			never	sometimes
Cigarettes	Girls	11	15	Cigarettes	Girls	8	18
	Boys	10	15		Boys	8	17
	In total	21	30		In total	16	35
Alcohol	Girls	4	22	Alcohol	Girls	3	23
	Boys	10	15		Boys	2	23
	In total	14	37		In total	5	46
Marijuana	Girls	21	5	Marijuana	Girls	16	10
	Boys	5	20		Boys	14	11
	In total	26	25		In total	30	21

Analyses of relationships between selected pathological phenomena and intensity of PA in research group was expressed through statistical testing chi-square.

Results of relationship analyses between level of PA and monitored addictive substances:

- Amongst girls and boys within research group smoking cigarettes is independent on the level of PA.
- Amongst children with high and low level of PA smoking cigarettes is independent on the sex.
- Amongst boys the alcohol consumption is dependant on the level of PA, amongst girls the alcohol consumption is independent on the level of PA
- Amongst girls the soft drug abuse is independant on the level of PA, amongst boys it is dependant on the level of PA.
- Amongst children with lower level of PA the soft drug abuse is independant on the sex, amongst children with higher PA it is dependant on the sex.

Conclusion

In this thesis we evaluated the connection between the level of PA and tendency of children towards drug abuse. Generally, amongst children with lower level of PA there is statistically significant amount of those who consume alcohol and abuse drugs. As for the smoking, we did not discover this tendency. The attitude of children is also different according to the sex.

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Appendix 1 – Statistics of the Chi-square procedures

H_{01}: Smoking girls are PA-independent cigarette smoking.
$X^2 = 0.14; p = 0.718$
We can not reject H_{01}, so girls are non-PA level cigarette smoking.

H_{02}: The boys are non-PA level cigarette smoking.
$X^2 = 0.01; p = 0.905$
We can not reject H_{02}, so the boys are non-PA level cigarette smoking.

H_{03}: Adolescents with lower PA are non-gender-specific cigarette smoking.
$X^2 = 0.01; p = 0.954$
H_{03} can not be denied, so nonporting adolescents are gender-neutral cigarette smoking.

H_{04}: Adolescents with higher PA are sex-independent cigarette smoking.
$X^2 = 0.10; p = 0.747$
H_{04} can not be denied, so in sporting adolescents, cigarette smoking is independent of sex.

H_{05}: For girls, alcohol consumption is PA-independent.
$X^2 = 1.11$; $p = 0.292$
We can not reject H_{05}, so for girls, alcohol consumption is PA-independent.

H_{06}: For boys, alcohol consumption is PA-independent.
$X^2 = 4.21$; $p = 0.040$
H_{06} is rejected, so in boys, alcohol consumption is PA dependent.

H_{07}: In adolescents with lower PA, alcohol consumption is gender-neutral.
$X^2 = 1.87$; $p = 0.172$
We can not reject H_{07}, so in adolescents with lower PA, alcohol consumption is gender-independent.

H_{08}: In adolescent sports, alcohol consumption is gender-neutral.
$X^2 = 0.22$; $p = 0.642$
We can not reject H_{08}, so in adolescents with higher PA, alcohol consumption is gender-independent.

H_{09}: In girls, use of soft drugs is PA-independent.
$X^2 = 2.34$; $p = 0.126$
We can not reject H_{09}, so girls are using soft drugs independent of PA levels.

H_{10}: In boys, the use of soft drugs is PA-independent.
$X^2 = 6.88$; $p = 0.009$
H_{10} is rejected, so in boys, the use of soft drugs is PA-dependent.

H_{11}: Adolescents with lower PA are the use of soft sex-independent drugs.
$X^2 = 0.16$; $p = 0.688$
We can not reject H_{11}, so adolescents with lower PAs are using sex-independent soft drugs.

H_{12}: Adolescents with higher PA are sex-neutral soft sex users.
$X^2 = 18.83$; $p = 0.001$
H_{12} is rejected, so adolescents with higher PA are sex-dependent soft sex users.
In girls, the use of soft drugs is PA-independent.

THE UTILIZATION POSSIBILITIES OF OXYGEN CONCENTRATORS´ INHALATION IN SPORT

Pupiš Martin, Pupišová Zuzana, Pavlík Ján
Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica, Slovakia

Abstract

The aim of research is to analyse the practical utilization possibilities of oxygen concentrators´ in a sport. Introduction contains a wide metaanalysis of researches realized on sportsmen, where variable methods of oxygen concentrator´s usage were used for improving performance and recovery. The main purpose of research is to point on variety of oxygen concentrator´s utilization in sport as well as on its limits. There is a presentation of author´s team members own researches, which they had realized in the past. Practical part of research is talking about oxygen concentrator´ inhalation and its impact to recovery in ice-hockey players. Twenty male players were tested, average age 23.53 years (SD ± 1,32), average weight was 81.83 kg (SD ± 10,62), average height 180.55 cm (SD ± 6,01 cm). Inhalation was realized on a New Life Intensity 2x10 l device, which can produce 90 % ± 3 % mixture of oxygen concentrator in a volume of 10 $l.min^{-1}$. Blood lactate value was diagnosed on a medical analyser EKF Biosen C line (measurement scale for lactate 0.5 – 40$mmol.l^{-1}$). Statistical analysis was calculated by IMB SPSS® V23 software. The repeated shuttle running test performance (4x10x10m) with different period of oxygen concentrator´ inhalation (0 sec. 30 sec., 60 sec., 90 sec. 120 sec.) were compared. We compared tests score, blood lactate concentration and heart rate parameters with using oxygen concentrator´s inhalation during test and without oxygen concentrator´s inhalation during test. There were significant differences in all periods of inhalation ($p<0.01$) respectively (30 sec., 60 sec., 90 sec., 120 sec.) compared to placebo control test without inhalation. When it comes about blood-lactate concentration we achieved significant differences ($p<0.01$) only during 120 seconds´ inhalation. In heart rate measurements, we found significant differences during 60 sec., 90 sec. And 120 sec. Inhalation. Based on these findings it is possible to assume that inhalation of oxygen concentrators might have positive impact on sport´s performance as well as on recovery processes in sport.

***Key words**: inhalation, oxygen, performance, recovery*

Introduction

Lately, there are lots of studies mentioning numerous possibilities of sport performance enhancement or efficiency increasement (Sýkora – Brünn, 2016). In the past, we made several researches about utilization of hyperoxia in sport. Hyperoxia is a state, where tissues or organs are subjected to abnormal oxygen O_2 supply, or abnormal dosages, than it is during normal oxygen parcial pressure (Mach et al., 2010). In medicine, hyperoxia is characterized as a state, where there is abnormal oxygen concentration in lunges and others tissues and this phenomenon might be caused by excessive air or oxygen inhalation during higher parcial pressure, than is the normal atmospheric pressure. This type of hyperoxia might bring toxicity of oxygen caused by detrimental effects of breathing molecular oxygen at higher parcial pressure. From this reason it is essential to be aware of numerous risks also during utilization in sport.

Suplementation of oxygen is common during hypoxaemia healing – abnormal low level of oxygen in blood. Hypoxaemia might cause tissue hypoxia if and only if the blood is not transporting enough oxygen to the remain organs and tissues and that brings a neccesity of another supplementation of oxygen. It is estimated, that yearly consuption of additional oxygen is moving around 800.000 people with more than 1.8 billion US dollars expances (Kim et al., 2014).

More researches are pointing on positive impact of hyperoxia on sport performance or recovery speeding up after high-intensity load (Harms, 2000; Morris et al., 2000; Peltonen, 2001; Wilber, 2004, 2003; Kay et al., 2008; Suchý et al., 2008a,b, 2010). On the other hand Murphy (1986) didn´t find any significant effect of oxygen concentrator´ inhalation mostly during medium lasting and long lasting activities. Similarly Robbins et al. (1992) and Yamyji – Shephard (1985) during short submaximal or maximal distance load. Máček (2011) actually targeted these activities as arguable with assuming, that inhalation of oxygen mixtures might improve blood oxygen level for about 1 ml on 100 ml blood. When we realise, that in 100 ml of blood there is 20 ml of oxygen, the improvement is 5 %. Máček (2011) is admiting, that the equation of balance between O_2 and CO_2 lasts up to 12 hours after activity and only several hours the excessive blood-lactate cleaning from organism is lasting. In our opinion it is necessary to understand, that higher oxygen supply to the body hypotheticaly might speed up the recovery remetabolization of blood-lactate in Cori´s cycle.

During realization of research we had been trying to come up from metaanalysis of our present researches, which in a large extent are showing possible positive impact of oxygen concentrators´ inhalation to the sport performance and post performance recovery processes.

Table 1. The comparison of hyperoxia impact on performance and recovery in various sports

Authors	Sport	Results
Pupiš, 2010	ahtletics	Performance improvement by 2.4 %
Pupiš et al., 2011	basketball	Lower heart rate 11% (p<0,05), lower blood-lactate level 25% (p<0,05), no changes in shooting accuracy.
Pupiš et al., 2013	judo/karate	Lower heart rate, lower blood-lactate level (p<0,05).
Pupiš et al., 2013	athletics	Performance improvement 1,4%.
Suchý et al., 2014	basketball	Lower blood-lactate level 3,2-5% (p<0,05), not significant impact on shooting accuracy.
Kremnický et al., 2014	gymnastics	Recovery speed up.
Pupiš et al., 2016	swimming	Performance improvement 6,89% (p<0,05).
Pupišová–Pupiš, 2016	swimming	Performance improvement 7,24% (p<0,05).

Methods

Twenty ice-hockey players participated in research, average decimal age was 23.53 years (SD ± 1,32), average weight of sample was 81,83 kg (SD ± 10,62), average height 180,55 cm (SD ± 6,01 cm). Inhalation was executed on New Life Intensity 2x10 l device, which is producing 90% ± 3 % mixture of oxygen concentrator in a capacity of 10 $l.min^{-1}$. Blood-lactate value was measured on analyser EKF Biosen C line (measurement scale for blood-lactate is 0.5 – 40 $mmol.l^{-1}$). Statistical analysis was made in IBM SPSS® V23. In our research, we compared repeated shuttle running 4x10x10 m performance time with blood-lactate level after finishing the test and maximal heart rate in the end of test. These parameters were compared without (placebo inhalation) and with oxygen concentrator´ inhalation with different period of inhalation time 30 sec., 60 sec., 90 sec. And 120 seconds respectively.

Results and Discussion

During data analyzing of results, we headed on achieved performance mostly, what is from a view of sport praxis the most important criterium. Naturally, from a view of sport sciences we considered appropriate the data also by a statistical support. As we can see on Figure 1, during comparison of achieved times in 4x10x10 m test we found the slowest performance during test without oxygen inhalation (placebo), reversely best performance was achieved during the longest oxygen inhalation (120 sec.). On Figure 1 you can also see that the longer oxygen inhalation´ time, the better time players achieved in test.

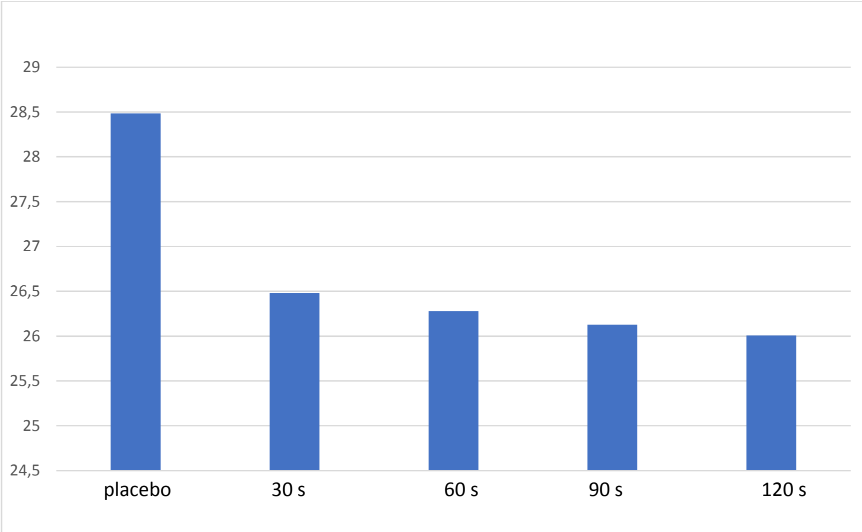

Figure 1. Comparison of achieved times in 4x10x10 m test

From a achieved time perspective in 4x10x10 m test we found significant differences ($p<0.01$) in all periods of oxygen concentrator´ inhalation (30 sec., 60 sec., 90 sec., 120 sec.) compared with placebo inhalation.

As well as the time achieved in test, same results were found in blood-lactate level. We found significant differences in all periods of inhalation compared to placebo. As you can see on Figure 2, the highest blood-lactate value was measured during placebo inhalation.

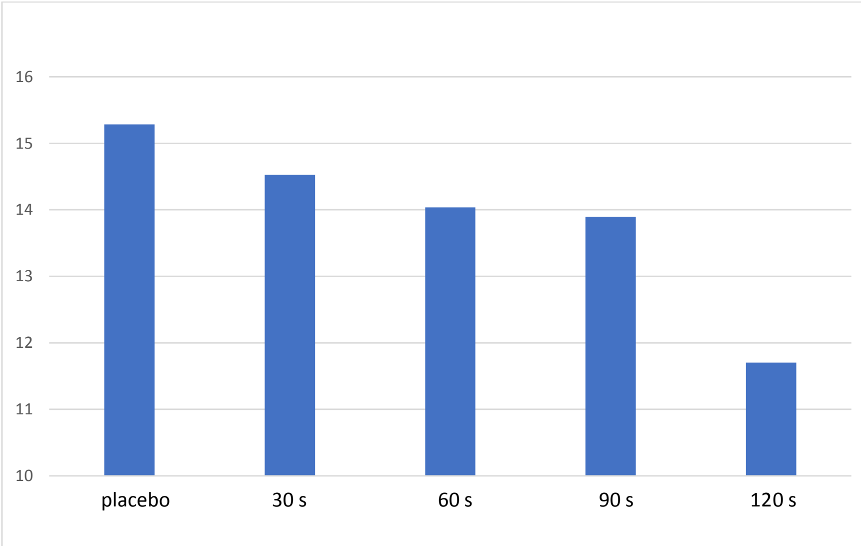

Figure 2. Comparison of lactate level after test

The lowest blood-lactate value was measured during 120 seconds oxygen concentrator´ inhalation, whereby there is a trend, that the longer time of oxygen concentrator´ inhalation, the lower blood-lactate values were achieved. Significant difference ($p<0.01$) compared to blood-lactate level without oxygen inhalation was achieved only during 120 seconds inhalation.

Similar trend we found during heart rate monitoring. On Figure 3, there is the highest heart rate value during placebo inhalation and the lowest during 120 second oxygen inhalation. Additionally, with lengthening oxygen inhalation time simultaneously the heart rate was decreasing.

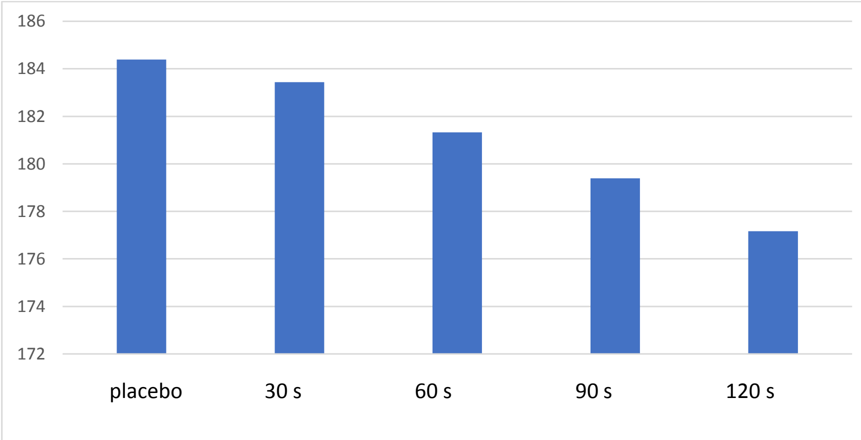

Figure 3. Comparison of lactate level after test

Likewise as it was with achieved time and blood-lactate level, during measurements of heart rate the trend was same. The longer oxygen inhalation time, the lower heart rate we tracked. There were significant differences ($p<0.01$) during comparison heart rate during placebo inhalation and 60, 90 and 120 seconds oxygen inhalation periods.

In a final Table 2 we summarized all significant differences and we can see, that from the achieved time perspective we found significant differences in all oxygen inhalation periods compared with placebo inhalation ($p<0.01$). From a blood-lactate perspective we found significant difference ($p<0.01$) only during 120 seconds lasting oxygen inhalation and during heart rate monitoring we found significant differences ($p<0.01$) in 60, 90 and 120 sec. oxygen inhalation.

Table 2. Statistical summary of results

	No inhalation	30 s inhalation	60 s inhalation	90 s inhalation	120 s inhalation
Time	28,483	26,482 (p<0,01)	26,278 (p<0,01)	26,128 (p<0,01)	26,006 (p<0,01)
Blood-lactate	15,285	14,526	14,037	13,896	11,704 (p<0,01)
HR	184,39	183,44	181,33 (p<0,01)	179,39(p<0,01)	177,16 (p<0,01)

Our results are indicating oxygen concentrators´ inhalation and its utilization potential in sport. In agreement with Harms (2000), Morris et al. (2000), Peltonen (2001), Wilber (2003, 2004), Kay et al. (2008), Suchý et al. (2008a, b, 2010) who are also presenting positive impact of hyperoxia on sport performance. It has to be noted, that positive impact is happening mostly during high-intensity anaerobic load or followed recovery after that. This corresponds with Murphy (1986), Robbins et al. (1992), who didn´t find any significant impact after oxygen inhalation primarily in sportsmen completing moderate to long lasting load. On a basis of our findings we assume, that demanded effect is showing during high-intensity load with duration up to 30 seconds, whereby the clearest effect happens after sufficient duration of inhalation, what in our research presents duration of 120 seconds.

Conclusion

Research results confirmed positive impact of oxygen concentrator´s inhalation to performance and recovery. During 4x10x10 m test we found significant differences ($p<0.01$) between achieved time without oxygen inhalation and with oxygen inhalation in all periods of inhalation (30 sec., 60 sec., 90 sec, 120 sec.). Empirical review revealed a trend, that the longer was oxygen inhalation, the better performance time was achieved (during 30 sec. improved about 2,001 sec., during 60 sec. improved about 2,205 sec, during 90 sec. improved about 2,355 sec. and during 120 sec. improved about 2,477 sec.). Despite the fact, that during all oxygen inhalation periods we found significant positive impact, we can assume that longer oxygen inhalation has stronger effect on performance. During blood-lactate level monitoring we found significant impact ($p<0.01$) of oxygen inhalation only during 120 sec. lasting inhalation time, but same as it was with performance we tracked decreasing blood-lactate levels with lengthening oxygen inhalation time. Finally during heart rate monitoring we found significant impact ($p<0.01$) of oxygen inhalation during 60, 90 and 120 sec. inhalation time with same observation, that the longer was oxygen inhalation time, the lower was heart rate achieved. According above mentioned results it is possible to assume, that oxygen concentrators´ inhalation might bring positive impact on sport performance, mostly anaerobic character ones. At last, it is necessary to consider, that every application of oxygen concentrators has to be individual with regarding on possible health risks and toxicity, which is the reason why oxygen inhalation might become a doping method in the future.

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PLYOMETRIC TRAINING (DEPTH JUMP) AND LEG MOTOR FITNESS OF MALE UNIVERSITY STUDENTS IN CZECH REPUBLIC AND NIGERIA

Sunday Arnold Akaninyene[1], Cacek Jan[2], Svobodová Lenka[2], Bílý Jiří[2], Adeniran Ajani Anuoluwapo[3]
[1]Faculty of Education, University of Calabar, Calabar, Nigeria
[2]Faculty of Sports Studies, Brno, Czech Republic
[3]Faculty of Sports and Health Sciences, University of Jyväskylä, Jyväskylä, Finland

Abstract

Leg motor fitness variables are essential parameters for the execution of skills involving the lower body and this could be effectively achieved with the utilization of the appropriate plyometric training. This study investigated the effect of depth jump (DJ) on leg motor fitness on male undergraduates of Czech Republic (CZ) and Nigeria (NG). The leg motor fitness variables selected for this study were leg muscular endurance (LME), leg power (LP) and speed (Sp). Experimental design was adopted for this study. Forty-eight participants were purposively selected, and these were drawn from Masaryk University of CZ (n = 24, age = 20.29±1.27, height = 183.29±6.73, weight = 76.45±8.48) and University of Calabar of NG (n = 24, age = 23.56±3.05, height = 173.03±7.48, weight = 63.81±8.83), and randomized separately in each country into DJ (n = 12), and control (n = 12). Training protocol was 4 seconds work, 5 seconds rest between works, 10 repetitions, 8 sets, 2 min between sets, totalling 30 min including warm-up and cool-down, twice per week for 8 weeks. Participants in CZ were measured using isotonic-squat with weight for LME, Myotest Pro for LP, and 10m dash using timing gate for Sp. While participants in Ng were measured using isotonic-squat with weight for LME, Sergeant Jump for LP, and 10m dash with stopwatch for Sp. MANCOVA was used to test the hypotheses at $p<.05$ and multiple bar graph for the research question. The findings showed that CZ DJ had a significant effect on LME and Sp with effect size (ES) 26.4% and 72.4% respectively, and NG DJ had a significant effect on LME and Sp, with ES 32.9% and 64.8% respectively. DJ was effective in both countries, but with higher ES in CZ. Differences in result could be attributed to level of intrinsic motivation, age, and level of physical activity. This study recommends that DJ should be incorporated in the regular routine of strength and endurance training.

Key words: *depth jump, endurance, speed, power*

Introduction

Sports that require powerful, propulsive movements, such as football, volleyball, sprinting, high jump, long jump, and basketball, involves the application of explosive jump training for enhanced leg motor fitness. In order to maximize potentials and maintain of high level of performance in sports and games, an athlete must possess a high level of skill and athletic fitness. These principally comprised cardiovascular endurance, muscular strength, muscular endurance and muscular power (Abass, 2009).

Plyometric training (PT) – exercises which enable a muscle to attain maximum force in the shortest possible time – has proven to result in improvement in the production of muscle force, speed, and power (McCormick, Hannon, Newton, Shultz, Detling, Young, 2016; Rodríguez-Rosell, Torres-Torrelo, Franco-Márquez, González-Suárez, & González-Badillo, 2017; Haff & Triplett, 2015; Maschi, Brindle, & Milner, 2016). Combined with qualified supervision and appropriate testing guidelines, PT can be a safe, effective, and reliable method of improving leg motor fitness in both athletes and non-athletes.

Exercise trainers have relied on practical experience and the methodology adopted during the design of resistance and aerobic training programs when prescribing PT exercise (Fleck & Kraemer, 2014). However, the mode of PT is primarily determined by the general part(s) of the body that are performing the given exercise (Newton, Murphy, Humphries, Wilson, Kraemer & Hakkinen, 1997), intensity – the amount of effort exerted by the muscles, connective tissues, and joints during the performance of an exercise and is controlled by both the type of drill and by the distance covered (Faigenbaum, Kraemer, Blimkie, Jeffreys, Micheli, Nitka & Rowland, 2009), frequency – number of PT sessions per week and depends on the client's age, ability, and goals (Swanik, 1999), recovery time – time between repetitions, sets, and workouts (Chu, 1998) between PT sessions, and volume – total work performed during a single workout session, is typically expressed as the number of repetitions and sets performed during a session (Chmielewski, Myer, Kauffman & Tillman, 2006). Plyometric progression takes place systematically, with proper landing position as the beginning point, it should progress slowly and focus on form, and all activities should be double leg until the client has fully adjusted to the stress (Henry, 1999). As with any training program, PT exercise session should not preclude general and specific warm-ups.

During the study, there existed a relationship between both universities as a result of Erasmus Mundus KITE II exchange program sponsored by the European Commission. And that collaboration involved Faculty of Sports Studies, Masaryk

University in the Czech Republic and Faculty of Education, University of Calabar in Nigeria. Therefore, the existed academic relationship necessitated this sports related related that was somewhat relatively new to both faculties. Czech Republic is a developed country is Central Europe, while Nigeria is a developing country with poor training infrastructure in west Africa. The purpose of this study was to compare the effect of depth jump PT (FJ) on leg motor fitness of male undergraduates of Czech Republic (CZ) and Nigeria (NG).

The improvement of depth jump was observed on vertical jump (Siti, Saat, Krasilshchikov, Shaw, & Shaw, 2014), standing long jump, speed, strength, and agility (Asadi, 2012; Singh & Singh, 2013), on power (Singh & Singh, 2012; Makaruk & Sacewicz, 2010), kinematic variables such as vertical velocity (Ghareb, 2014). Carvalho, Mourao, and Abade (2014) showed that strength training program combined with specific PT had a significant effect on body composition, vertical jump height and strength development of lower limbs. Arazi's (2012) study also confirms that dynamic balance, agility, vertical jump, and sprint performance of young male basketball players can be significantly improved by a high-intensity plyometric training program. Ramirez-Campillo, Andrade, Alvarez, Henríquez-Olguin, Martinez, Baez-SanMartin, Silva-Urra, Burgos, and Izquierdos' (2014) research showed that the recovery time – 20s, 60s, or 120s – between repetitions is immaterial because similar significance observed relative to the effect of PT.

Methods

Experimental Approach to the Problem: An experimental, randomized pre-test posttest comparative study design was employed. Forty-eight participants (i.e. 24 per university) were purposively selected from Masaryk University (MU), CZ and University of Calabar (UNICAL), NG, and randomized separately in each university into DJ (n = 12) and control (n = 12). The participants were assessed on leg muscular endurance, power, and speed pre and post 8 weeks of depth jump training.

Participants: First year male students at both universities were duly informed about the nature of the research, and they signed an informed consent form questionnaire approved separately by the Internal Review Boards at the universities. Twenty-four male undergraduates ([mean ± SD] age: 19.75 ± .8 years, weight: 73.758 ± 10.5 kg, height: 182.08 ± 7cm) from CZ, and twenty-four male undergraduates (age: 23.75 ± 2.9 years, weight: 63.67 ± 7 kg, height: 172.50 ± 7.5 cm) from NG volunteered to participate in the research. The participants were screened for any medical or orthopedic issue that could limit participation prior to commencement. The forty-eight participants had to be inexperienced in plyometric training, and successfully completed a total of sixteen sessions of the study.

Procedure

Training: The program lasted for a period of about 12 weeks each for both countries. The first two weeks was used for the pretest measurement for leg muscular strength, leg muscular endurance, leg power, and speed, while the last two weeks was used for the posttest measurement of the same variables that were measured during the pretest. 8 weeks were used to administer the intervention program of the plyometric training mode of depth jump. Training of all participants took place two times in a week, Mondays and Thursdays.

Each training session was preceded by a warm-up which lasted for 5 minutes, and concluded with a cool down of about 5 minutes. The warm-up was made up of exercises like dynamic leg stretches, sit ups, light jogging, and lunges. The interval training was used in the training program for this study. The training is made up of series of work intervals interspersed with relief ratio of 1:5. The prescription adapted for this study was 5 seconds rest between DJ, 10 repetitions, 8 sets, and 2 minutes between sets (self-faced running). The total duration for each session per day was 30 minutes including warmup and cool down. The training protocol was the same from week 1 to week 8 in both CZ and NG.

Testing: Participants were tested pre and post the 8-week training period. Myotest (JUMP – CMJ) was used to measure leg power in the CZ. The Myotest was wrapped round the waist of the participants, a maximum jump height was made, movement was executed energetically so that the myotest could clearly detect it, and position during the waiting phase for the beep was maintained. Squat with weight [a barbell weighing 32 kg (bar = 20 kg, endplates = 2.5 kg × 2 = 10 kg, hex bolt = 1 kg × 2 = 2 kg), an AX605 Accusplit AX Pro Stopwatch (model 00033A, Lafayette, USA), and a bench of 42 cm high] was used to measure leg muscular endurance. The participants were instructed to carry the weight for 1 minute, and the number of repetitions then recorded. 10m dash using timing gate was used to measure speed in the CZ. While the readings on the timer was zero, each participant ran at his maximal speed through the timing gate. Running through with maximal speed by the participants is done twice, interspaced by 10 minutes. The best time is then recorded in seconds and milliseconds. Isokinetic dynamometer was used to measure leg muscular endurance. The tester sat and stabilized the participants, and runs the test for two minutes.

Sergeant Jump Test was used to measure leg power in NG. The participant stood siding a wall and reached up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips was marked or recorded. The participant then stood away from the wall, and leaped vertically as high as possible using both arms and legs to assist in projecting the body upwards. The jumping technique used a countermovement. Attempted to touch the wall at the highest point of the jump. The best of three attempts was recorded.

Limitations of the study

The limitations of this study were the differences in the training environment, the instruments used during the pre and post testing, and the relatively differences in the subjects. For example, the differences in the levels of testosterone the Nigerians compared to the Czechs.

Statistical Analysis

The descriptive statistics of mean, standard deviation, and multiple bar graph, and inferential statistics of Multivariate Analysis of Co-variance (MANCOVA) at $p < .05$ were used to analyse the data. Multiple bar graph was used for the comparison between both universities. That was so because despite the differences in the instruments used and their reliabilities, there were still size effects of the depth jump on the selected leg motor fitness variables.

Results

After 8 weeks of depth jump training, the result on table 1 and 2 showed there was a statistically substantive effect of depth jump training on leg motor fitness in the CZ, $F (4, 15) = 12.181$, $p < .0001$, Pillai's Trace = .765. Examining the result further, the details showed that depth jump training had statistically substantive effect on leg muscular endurance, $F (1, 18) = 6.465$, $p < .020$, partial $\eta 2 = .264$, with 26.4% effect size accounted for by the training. Also, it revealed that there was a statistically high substantive effect of the training on speed, $F (1, 18) = 47.264$, $p < .000002$, partial $\eta 2 = .724$, with 72.4% effect size. There was no substantive effect of depth jump training on leg power, $F (1, 18) = 1.395$, $p < .253$, partial $\eta 2 = .072$, with 7.2% effect size.

Table 1. Descriptive statistics of depth jump training on power, endurance and speed in CZ

	Contr (n=12)		Exp (n=12)	
Performance Indices	Pre-test	Posttest	Pre-test	Posttest
Power (cm)	48.01± 11.22	48.59 ± 14.89	46.84 ± 7.36	49.89 ± 9.18
Endurance (rdmin-1)	23.72 ± 9.39	23.92 ± 5.84	26.83 ± 7.90	29.50 ± 6.40
Speed (s)	1.85 ±. 11	1.85 ±. 39	1.96 ±. 06	1.38 ±. 04

Table 2. Summary of MANCOVA showing effect of Depth Jump on power, endurance and speed in CZ

Source	Depend. Variable	Pillai´s Trace	F	df	P	Sum of Square	df	Mean Squared	F	P	Partial η2
		.765	12.181	15	.000						
Depth	Power					79.620	1	79.620	1.395	.253	.072
Jump	Endurance					57.474	1	57.474	6.465*	.020	.264
	Speed					.080	1	.080	47.264*	.000	.724

*p< .05

Table 3 and 4 showed that there was a statistically substantive effect of depth jump training on leg motor fitness in NG, $F (4, 15) = 18.817$, $p < .00001$, Pillai's Trace = .834. Further details indicated that depth jump training had a statistically substantive effect on leg muscular endurance, $F (1, 18) = 8.827$, $p < .008$, partial $\eta2 = .329$, with 32.9% effect size accounted for by the training. The training also had a statistically significant effect on speed, $F (1, 18) = 33.103$, $p < .00001$, partial $\eta2 = .648$, with 64.8% effect size accounted for by the training. There was no substantive effect of the training on leg power, $F (1, 18) = 1.005$, $p < .329$, partial $\eta2 = .053$, with 5.3% effect size. Hence, comparing the ES for both countries showed that depth jump training for Czech Republic was most effective.

Table 3. Descriptive statistics of depth jump training on power, endurance and speed in NG

	Contr (n=12)		Exp (n=12)	
Performance Indices	Pre-test	Posttest	Pre-test	Posttest
Power (cm)	38.13 ± 5.49	38.10 ± 4.43	39.10 ± 4.16	43.61 ± 15.48
Endurance (rdmin-1)	22.92 ± 3.32	22.92 ± 3.92	23.00 ± 4.24	24.91 ± 4.89
Speed (s)	1.85 ±. 042	1.85 ±. 097	1.87 ±. 06	1.52 ±. 11

Table 4. Summary of MANCOVA showing effect of Depth Jump on power, endurance and speed in NG

Source	Depend. Variable	Pillai´s Trace	F	df	P	Sum of Square	df	Mean Squared	F	P	Partial η2
		.765	12.181	15	.000						
Depth	Power					98.153	1	98.153	1.005	.253	.053
Jump	Endurance					16.643	1	16.643	8.827*	.008	.329
	Speed					.049	1	.049	33.103*	.000	.648

*p< .05

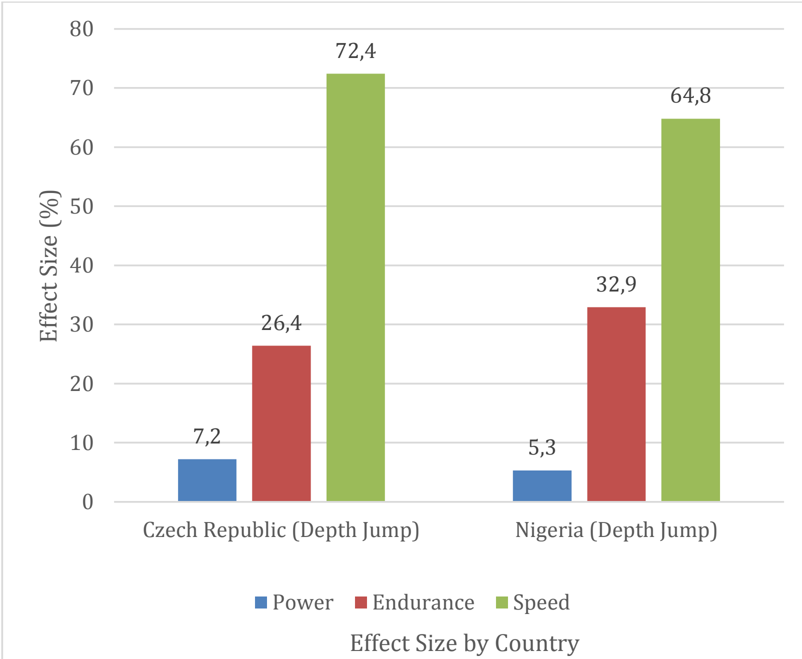

Figure 1. Multiple bar graph showing comparison of depth jump training in CZ and NG

For a better overview, the data was transformed into a graph. We can see the comparison of depth jump training in CZ and NG. The result on the graph indicated that the depth jump was better seen on speed and power of the Czechs than on the Nigerians. But the effect on strength was more for the Czechs, perhaps because of the higher level of testosterone in Nigerians.

Discussion

The statistical analysis of hypothesis one of this study has exposed us to the fact that there was a very large overall statistically substantive effect of depth jump on leg motor fitness of male undergraduates in CZ and NG following an 8-week training program, mainly with regards to leg muscular endurance and speed. However, there was no significant effect of depth jump training on leg power and leg muscular strength. This is in consonance with Mirzaei et al. result (2014) which revealed that depth jump training had a significant effect on leg motor fitness variables such as speed. Mirzaei et al. emphasized that the effectiveness of depth jump training was better achieved when perform on sand. However, the depth jump training in CZ, was performed in an indoor gym with hard floor. Corroborating this further, Singh et al. (2012) asserted that progressive depth jump training was effective on male athletes but induced specific adaptations on trainees. Asadi (2012), Arazi (2012) and Singh et al (2013) reiterated that depth jump training should be recommended for use by coaches to improve speed. Contrary to this study, Siti et al. (2014) observed that depth jump training improved leg muscular power. It is important to note that Siti's study was conducted on children. This position was also supported by Mateesu (2013) who posited that provided a statistically significant and practically relevant improvement on leg muscular power. Surprisingly just like this study, Mateesu's study was carried out on untrained males. The magnitude of effect showed that depth jump caused more effect on speed of untrained males in CZ. The differences in result was not confirmed during this study, but could be attributed to level of intrinsic motivation, age, and level of physical activity.

The differences in the effect of DJ on leg muscular endurance, leg power, and speed may have been the difference between the intervention and testing exercises. Transfer between these exercises may had affected overall results. Also, the differences between CZ and NG could have been caused by a different prior experience DJ training.

Conclusion

This research buttresses the significance of the inculcation of DJ in the training regimen of individuals or athletes that aims to improve speed and perhaps strength performance particular for the lower extremities. Specific execution of skills may however be pivotal to the magnitude of the resultant training effects. It is not clear if DJ could be as effective for the improvement of leg endurance or fitness as not many study has reported such effects. However, DJ appears to have the potential to help improve different leg motor fitness variables if channelled properly.

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CREATINE KINASE LEVELS AFTER COMPETITION MATCH AND ITS RELATION TO PLAYER´S POSITION IN ELITE SLOVAK SOCCER TEAM

Sýkora Jozef, Brűnn David, Pupiš Martin
Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica, Slovakia

Abstract

Regular season in soccer often brings overloading of players therefore it is highly important to implement some fatigue controling mechanisms for minimazing the risk of injury. Many authors investigated which methods could be used for reliable measurement of fatigue and injury prevention in elite soccer and since technology is always moving forward the necessity of next research is essential. The main purpose of this study was to monitor creatine kinase levels after competition matches on proffesional Slovak league soccer team via new non invasive method which is faster and more comfortable for players and defining differences of CK on player´s position. Soccer team consisted of 19 players (Age 24.4 ± 4.84, Height 181.75 ± 3.87, Weight 77.50 ± 6.16). Two goalkeepers, six defensemen, seven midfielders and four forwards were tested respectively. Players took a part in measuring of creatine kinase 16 hours after competitive match during 6 measurements in regular season. Reflotron Plus device was used for measuring creatine kinase levels via non invasive principle of reflectance photometry. There were increased CK levels in all players average about 4.62 ± 1.56 μkat.l-1 in goalkeepers, 6.79 ± 4.29 μkat.l-1 in defencemen, 7.56 ± 5.59 μkat.l-1 in midfielders and 7.68 ± 5.40 μkat.l-1 in forwards. Globally we achieved increased CK levels during 80% from all measurements compared to reference values of CK for sportsmen. There were significant differences with moderate effect size between CK levels of goalkeepers and defencemen ($p = 0.05$, $r = 0.32$), goalkeepers and midfielders ($p = 0.05$, $r = 0.34$) and goalkeepers and forwards ($p = 0.05$, $r = 0.36$). We found no significant differences between defencemen, midfielders and forwards. We strongly recommend regular measuring of CK levels after every match due to decreasing risk injury and overload in players, since many authors approved significant connection between high CK levels and frequency of injuries. CK levels´ monitoring might be efficient for optimising the training process between the matches during season.

***Key words**: elite soccer players, creatine kinase, position, training, match*

Introduction

Competitive sport in all fields is becoming more aggresive and intense and so the sportsmen are forced to be stronger and faster. Same trend appears in sports games such as soccer, where season is long and players have to perform their best on a regular basis. Due to that they need to train almost daily and despite their active recovery the risk of injury is tremendously increasing. According Psotta et al. (2006); Votík, Zalabák, Bursová & Šrámková (2011) during 1 football match players complete activities with duration between 1-5 seconds in high or maximal intensity, 5-10 seconds in low intensity or inactivity. Average covered distance of player is moving from 9-11 km (in goalkeepers only up to 4 km). 25-27% of distance is covered by walking, 37-45% by jogging, 6-8% by reverse running and 6-11% by sprint or fast running. The rest is covered by game actions. Players are sprinting the most often on a distance of 15-30 m, which is around 0,8-1 km per match and 1 sprint is repeating average about every 90 seconds. Only 1-3 minutes is spent by contact with a ball and player is in contact with the ball average about 70-90 times per match. When it comes about player´s position goalkeepers and central defenders are covering smaller distance with lower intensity than midfielders and wingbacks and forwards are covering similar distance and intensity than wingbacks but higher number of sprints. With that fact coaches need a valid method how they could diagnose overload in players and somehow keep the risk of injury as low as and in the same time utilise the players as often as necessary. One of the biochemical method is to record creatine kinase levels. Thompson, Nicolas & Williams (1999); Smith (2000); Chevion et al. (2003); Neuman, Pfützner, & Hottenrott (2000); Máček, Macková, & Radvanský (2003); Laczo (2011) and Voháňka (2012) are clasifying creatine kinase as an enzyme which is responsible for phosphorylation of ADP into ATP. While during normal circumstances creatine kinase is present in blood, during overload the muscle is damaging and creatine kinase levels are highly increasing. The highest concentration of creatine kinase can be seen 6-8 hours later. These authors also show average values of creatine kinase for men between 0.2 – 3.8 $\mu kat.l^{-1}$, but we can often see higher values in sportsmen. The levels of creatine kinase can be affected by unexpected stimulus such as unexpected muscle load, intense muscle work, long term muscle work, muscle stiffness or injury. When it comes about player´s position there could be more factors affecting the results. Kubayi, Paul, Mahlangu & Toriola (2017) found out, that goalkeepers and defenders are usually heavier than midfielders and forwards. Goalkeepers have highest body fat percentage and midfielders and defenders have higher VO_2 max than goalkeepers and forwards. Due to these facts it is important to carefuly make conclusions in contact sports. When it comes about soccer several authors tracked increased creatine kinase levels up to 72 hours after competition match. (Jaffe, Garfinkel, Ritter, Sobel (1984); Ascensão, Rebelo, Oliveira, Marques, Pereira, & Magalhães (2008); Ispirlidis et al. (2008)). Can we reliable prevent injury by monitoring creatine kinase levels in soccer team?

The aim of this study was to monitor the creatine kinase levels after competition matches via non invasive method which is faster and more comfortable for players. Therefore to assess differences between creatine kinase levels on players positions in soccer team.

Methods

Research lasted since 27. february 2017 by 2. april 2017 period where 6 measurements were realized (1x friendly match, 5x competition match). Sample consisted of 19 professional soccer players (Age 24.4 ± 4.84, Height 181.75 ± 3.87, Weight 77.50 ± 6.16) of slovak Fortuna league team (finished in top 5 in season 2016/2017). Two goalkeepers, six defensemen, seven midfielders and four forwards were tested respectively. All measurements were made 16 hours after previous competition or friendly match. Non specific period 16 hours after match was chosen in order to early correction of training process due to CK measurements results and so the effort was to prevent possible injury that might occur by applying inadequate load on players. For data observation of creatine kinase the Reflotron Plus device was used. Reflotron Plus is diagnostic device which works on a principle of reflectance photometry. Reflotron non invasive principle consists of reflection measurements with Ulbricht sphere, compensation principle of the reference beam method Light sources: Light-emitting diodes (LED´s) Wave lengths: 567 nm, 642nm, 951nm. It is not require a calibration, it can store up to 60 results and one measurement lasts between 2-3 minutes. (It can produce 18-30 tests in a hour). 17 parameters can be choose to be diagnosed and it is needed to measure during 37° C ± 0.1 °C temperature with possibility of conversion to 25 °C or 30° C. For data evaluation descriptive analysis was used and calculated statistical significance (F-test-two sample for variances, t-test-two sample assuming equal/unequal variances) and effect size in SPSS and Microsoft Office software. In addition others qualitative methods were used.

Results

Research consisted of 80 measurements divided on players position. For better interpretation we present results in Table 1.

Table 1. CK levels according player position

	Number of players	Number of totall measurements	Average CK levels	Minimum CK	Maximum CK
Goalkeepers	2	7	4.62 ± 1.56 µkat.l-1	3.22 µkat.l-1	**7.17** µkat.l-1
Defencemen	6	25	6.79 ± 4.29 µkat.l-1	1.18 µkat.l-1	**20.9** µkat.l-1
Midfielders	7	31	7.56 ± 5.59 µkat.l-1	1.73 µkat.l-1	**25.6** µkat.l-1
Forwards	4	17	7.68 ± 5.40 µkat.l-1	0.41 µkat.l-1	**19.4** µkat.l-1

In Table 1 there are some basic information about numbers of tested players on each position, totall number of measurements per position and average values of CK measured 16 hours after competitive match. All players actively participated during match. CK levels oscilated and it might be caused due to shorter play-time of players who have been substituted during match. Due to this fact, see APPENDIX A, where players who played less than 30 minutes are red marked.

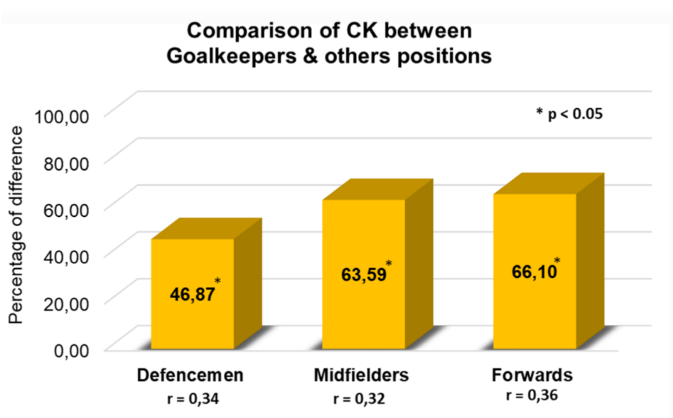

Figure 1. Percentage, T-test, Effect size comparisson of GK and others positions

As you can see in Figure 1 compared to goalkeepers we recorded higher CK levels in defencemen (46.87 %), midfielders (63.59 %) and forwards as well (66.10 %).

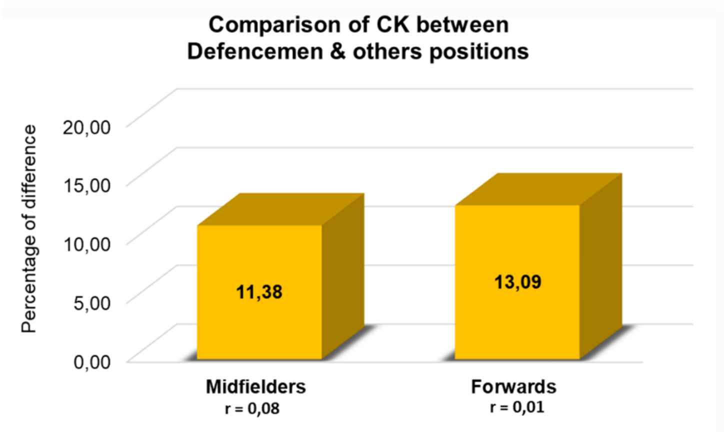

Figure 2. Percentage, T-test, Effect size comparisson of D and others positions

Figure 2 presents comparisson between defencemen with midfielders and forwards. When it comes about defencemen comparisson we recorded higher CK in midfielders (11.38 %) and also forwards (13.09 %).

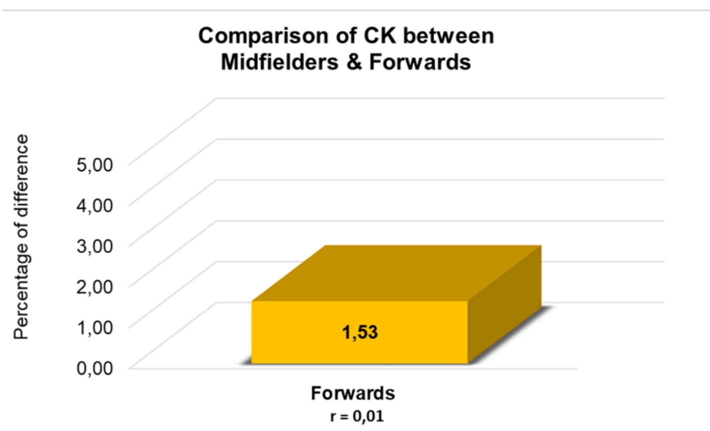

Figure 3. Percentage, T-test, Effect size comparisson of Midfielders and Forwards

Finally in Fig. 3, there was slightly higher CK levels achieved in forwards compared to midfielders (1.53 %).

For assessment whether there are any significant differences between achieved CK values and player´s position we calculated F-test of two samples for variance followed by two sample assuming equal/unequal variances t-test. Additionaly we calculated effect size coeficient as well due to supporting reliability of our measurements. As you can see from Fig. 1, Fig. 2 and Fig. 3 we found significant differences with moderate effect size in CK levels between goalkeepers and defencemen ($p = 0.05$, $r = 0.32$), goalkeepers and midfielders ($p = 0.05$, $r = 0.34$) and goalkeepers and forwards ($p = 0.05$, $r = 0.36$). This might by caused due to less activity of goalkeepers during matches, despite the fact that landing after saves could influence CK levels. Since landing techniques are part of training process it seems that goalkeepers are use to it so far this factor is neglectable. There were no significant differences and small effect size values between defencemen and midfielders ($p = 0.58$, $r = 0.08$), defencemen and forwards ($p = 0.56$, $r = 0.01$) and also midfielders and forwards ($p = 0.94$, $r = 0.01$).

According several authors such as Máček, Macková, & Radvanský (2003); Laczo (2011) or Voháňka (2012) the reference value for determining whether the CK level is increased above normal in sportsmen is established at 3.2 µkat.l-1. In Table 2 we compared, how many times CK levels achieved above average level according this scale.

Table 2. Frequency of CK level´s elevation above normal reference value

	> 3.2 µkat.l-1	< 3.2 µkat.l-1	Totall number of measurements
Goalkeepers (GK)	7	0	7
Defencemen (D)	21	4	25
Midfielders (Mdf)	23	8	31
Forwards (F)	13	4	17
Together	**64**	**16**	**80**

In Table 2 you can see that from all 80 measurements we achieved increased CK level above average reference level in 64 times, what presents 80% of all measurements. This fact only confirm the already known idea, that competitive match is causing muscle damage and increasing CK levels.

For determining, if increased CK levels affected players performance we collected matches statistics presented in

Table 3. During research period, the team achieved 4 draws and 2 loses from 6 matches with 5 scored goals and 6 scored goals against. This uncomplimentary result statement might be caused by overloading of players since 80% of CK measurements were elevated above normal reference value.

Table 3. Statistics from played matches

	Number of Matches	Shots	Shots on target	Saves	Yellow cards	Ball Possession
Total	6	42	16	19	12	x
Average	x	8.40 ± 2.07	3.20 ± 1.64	3.80 ± 2.05	2.40 ± 1.14	51.80 ± 3.11

In Table 3 you can see the additional statistics of played matches. Players achieved 12 yellow cards and got a ball possession over 50% in most of the matches, average shots per match moved around 3.20 ± 1.64 and goalkeepers saves moved around 3.80 ± 2.05 per match. This can create globally a clear image of CK values and team competitive performance.

Discussion

Competitive matches during season are causing high fatigue in elite soccer players therefore it is necessary to adjust intensity and difficulty of training process up to 72 hours after competition match during regular season if minimalization of injury is our main task. We found out elevated creatine kinase levels 16 hours after competitive match in elite slovak soccer players. This correspond with Lazarim et al. (2007) who successfuly monitored 124 players of Brazilian league during season and set upper safe limit of CK levels before overloading in players. He monitored also injuries in players whos CK levels were higher than recommended. As a upper limit of CK level Lazarim et al. (2007) set a CK level 16.25 $\mu kat.l^{-1}$ which when it is achieved, there is more than 95% probability, that player will injure. Although during our research we achieved this high CK level only in 6 from 80 measurements (7.5 %) , in 80 % of measurements we achieved elevated CK levels above average. This fact could be cause of decreased results of team, when from 6 matches they achieved not a single win. Russel, Sparkes, Northeast, Cook, Bracken & Kilduff (2016) succesfully found relationship between high intensity distance covered and number of sprints during match with 24 hours post match elevated CK values and decreased CMJ performance. They found no statistical association after 48 post match measurements. Many other authors also tracked CK levels after competitive match and achieved increased CK levels between 8 to 72 hours after match (Silva, Ascensão, Marques, Seabra, Rebelo and Magalhães (2013)). Hankin, Fahrner & Gastin (2014) were measuring CK levels during whole season and they found out, that during season average CK value of player pre-match was 485% higher than player baseline value before start of the season. They also found significant correlation between decreased player performance and elevated pre-match CK level ($p<0.05$), but they also found a possibility to substitute this decreasement in performance by player´s experience level (number of played matches). This corresponds with our findings. According above mentioned information we strongly recommend to all coaches to monitor creatine kinase levels in players on a regular basis and depends on that adjust training process for avoiding injuries in players. 48 hours seems to be sufficient for recovery after match, although during season we have to keep in mind residual muscle damage and possible elevated CK level during whole season. Competitive match seems to cause significant higher physiological response in defencemen, midfielders and forwards than in goalkeepers, what might be linked with fact, that during match goalkeepers´ CK levels are elevating due to muscle damaging by landing (mechanically) and so their recovery after match is faster compared to players, where muscle damage is more likely caused by physical contact and energy depletion. That´s why the CK levels in our research were highest in midfielders and forwards who spent the most energy during matches. It would be efficient to monitor CK levels on a daily basis, which is our suggestion for a future research for figuring out, if CK levels are elevated permanently or only after matches.

Conclusion

Soccer is one of the sports, where high level of fatigue in players is occuring up 72 hours after competition match. With energy depletion it comes also muscular damaging and if we want to minimize chance for injury, it is highly efficient to monitor a fatigue in players. Reliable and valid method for monitoring muscular damage and fatigue is measuring the creatine kinase levels In our research non invasive method of measuring CK levels was used for monitoring CK levels in elite slovak soccer team, where we measured CK levels 16 hours after competition match for a period of 7 weeks. We found out increased creatine kinase levels 16 hours after competitive match in elite slovak soccer players above average reference level in 80% of measurements. Compared to Lazarim et al. (2007) recommendations for upper limit of CK to prevent injury, only 6 of all measurements achieved above this limit in our research. Physiological response seems to be significantly stronger in defencemen ($p = 0.05$, $r = 0.32$) , midfielders ($p = 0.05$, $r = 0.34$) and forwards ($p = 0.05$, $r = 0.36$) compared with goalkeepers, which might be caused by character of CK elevation, when in defencemen, midfielders and forwards energy depletion and physical contact play a huge role during muscle damaging. According above mentioned information we strongly recommend to all coaches to monitor creatine kinase levels in players on a regular basis and depends on that adjust training process for avoiding injuries in players. It would be needed a future research for determining, whether CK levels are elevated in players permanently or only after match.

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APPENDICES

APPENDIX A Players data

friendly match
6 substitutions

	Position	Age	Height (cm)	Weight (kg)	CK 27.02.2017	CK 06.03.2017	CK 08.03.2017	CK 13.03.2017	CK 27.03.2017	CK 02.04.2017
P1	defenceman	31	180	77	4.6 µkat.l-1	5 µkat.l-1	x	6.8 µkat.l-1	1.2 µkat.l-1	4.8 µkat.l-1
P2	defenceman	25	187	84	11.6 µkat.l-1	3.22 µkat.l-1	x	9.93 µkat.l-1	2.23 µkat.l-1	20.9 µkat.l-1
P3	defenceman	20	182	73	2.53 µkat.l-1	x	x	3.56 µkat.l-1	x	x
P4	defenceman	28	187	87	7.2 µkat.l-1	7.59 µkat.l-1	8.14 µkat.l-1	7.09 µkat.l-1	2.75 µkat.l-1	5.39 µkat.l-1
P5	defenceman	27	176	72	7.46 µkat.l-1	12.5 µkat.l-1	6.82 µkat.l-1	x	x	x
P6	defenceman	24	186	78	3.72 µkat.l-1	x	x	10.2 µkat.l-1	3.51 µkat.l-1	11 µkat.l-1
P7	goalkeeper	35	184	90	4.02 µkat.l-1	7.17 µkat.l-1	3.22 µkat.l-1	5.35 µkat.l-1	x	5.98 µkat.l-1
P8	goalkeeper	26	181	77	3.26 µkat.l-1	x	x	x	3.35 µkat.l-1	x
P9	midfielder	20	177	76	2.65 µkat.l-1	3.11 µkat.l-1	x	x	x	x
P10	midfielder	28	180	81	12 µkat.l-1	x	8.15 µkat.l-1	25.6 µkat.l-1	3.61 µkat.l-1	17.4 µkat.l-1
P11	midfielder	36	174	70	5.95 µkat.l-1	8.27 µkat.l-1	2.98 µkat.l-1	x	3.98 µkat.l-1	6.73 µkat.l-1
P12	midfielder	29	185	70	11.1 µkat.l-1	3.16 µkat.l-1	x	18.7 µkat.l-1	3.21 µkat.l-1	3.77 µkat.l-1
P13	midfielder	23	185	71	6.73 µkat.l-1	8.62 µkat.l-1	2.51 µkat.l-1	8.96 µkat.l-1	2.87 µkat.l-1	8.56 µkat.l-1
P14	midfielder	28	182	84	4.45 µkat.l-1	11 µkat.l-1	2.9 µkat.l-1	15.2 µkat.l-1	1.73 µkat.l-1	9.44 µkat.l-1
P15	midfielder	27	172	78	x	7.82 µkat.l-1	3.21 µkat.l-1	x	x	x
P16	forward	21	182	74	8.11 µkat.l-1	7.73 µkat.l-1	2.71 µkat.l-1	x	2.45 µkat.l-1	6.63 µkat.l-1
P17	forward	22	180	75	9.78 µkat.l-1	19.4 µkat.l-1	8.85 µkat.l-1	14.2 µkat.l-1	5.58 µkat.l-1	11.2 µkat.l-1
P18	forward	26	181	71	x	17.6 µkat.l-1	5.57 µkat.l-1	0.4 µkat.l-1	x	x
P19	forward	26	181	78	x	x	x	3.94 µkat.l-1	3.51 µkat.l-1	2.83 µkat.l-1

players played less than 30 minutes