RELATIONSHIPS BETWEEN PHYSICAL ACTIVITY, MOTOR PERFORMANCE AND BODY COMPOSITION IN SCHOOL-AGE CHILDREN

https://doi.org/10.5817/CZ.MUNI.P210-9631-2020-28

Pavol Čech, Pavel Ružbarský

University of Prešov, Faculty of Sports, Prešov, Slovakia

ABSTRACT

Introduction: Physical activity (PA) performed at recommended levels is associated with multiple health benefits. However, as indicated by the available studies, the volume of habitual physical activity of children continuously decreases.
Aim: The aim of the study was to assess the relationships between physical activity performed by school-age population and indicators of motor performance and body composition.
Methods: The research group consisted of 144 students of the primary school assigned into groups according to the years of study (first, fifth and eighth-year students). The amount of physical activity was examined through a non-direct method, using Fels PAQ, recording four scores, namely sport index, leisure index, work (chore) index and total score. Body composition was tested using a direct segmental multi-frequency bioelectric impedance analysis (DSM-BIA). Motor performance was assessed in four categories. Endurance and strength endurance were assessed using Jacik's motor test; strength abilities were measured using a hand grip test; speed abilities were tested in linear sprints at 5 and 10 meters and in the test of speed with changes of direction at 4 x 10 m and, finally, explosive strength was assessed from results of the countermovement jump (CMJ), squat jump (SJ) and 10-second repeated jumps tests. The strength of association between the selected factors was determined from the results using the Spearman's rank correlation analysis.
Results: The amount of physical activity was mainly associated with the indicators of active body mass (fat free mass, skeletal muscle mass) in all age categories. Low association was found in the parameters of adipose tissue (body fat percentage, visceral fat level). When assessing the strength of association between the characteristics of motor performance and physical activity performed, we observed various courses of associations, based on which it is not possible to determine the tendency. When assessing the relationship between the amount of physical activity and motor performance of students regardless of age, we found medium association only with indicators of strength abilities (hand grip test) and characteristics of speed abilities.
Conclusions: The results are not explicit but they point to some tendencies in relationships between habitual physical performance and body composition indicators. With respect to motor performance, it is not possible to consider these results decisive; therefore, further data collection and more accurate assessment of relationships are necessary.

Keywords: habitual physical activity; Fels PAQ; active mass; adipose tissue; physical performance

Introduction

Generally, children are the most active part of population and this fact is based on their biological needs. Physical activity in any form shall be an integral part of one's everyday life. Physical activity is fundamental to the early development of each child and affects many aspects of a child's health (King et al., 2003). Regular participation in physical activity helps reduce the health risk of childhood obesity and the associated chronic diseases (Gao, Chen, Sun, Wen, & Xiang, 2018). The support for physical activity in childhood is essential since, as declared by Larsen, Kristensen, Junge, Rexen, & Wedderkopp (2015), physical activity habits developed in childhood tend to persist into adulthood.

Positive effects of physical activity have been sufficiently reported. Generally, it is believed that there is a linear relationship between performed physical activity and motor performance (Zapletalová, Antala, Doležajová, Labudová, & Lednický, 2011), when children with higher levels of adiposity display lower motor performance scores, and children with lower motor performance scores participate in less physical activity than peers with higher motor performance abilities (Morrison et al., 2012). Physical activity is a tool for maintaining physical and mental balance that can result in increased fitness, performance, self-confidence and self-fulfilment and self-confirmation (Bendiková, 2014). A direct impact of physical activity performed by children was, in the latest studies, reported in the context of motor performance (Morrison et al., 2012; Larsen et al., 2015), cognition and academic performance (Donnelly et al., 2016) and health (Gao et al., 2018).

The present time offers a broad spectrum of many different kinds of leisure activities. Despite the well-known benefits of physical activity for human health, in recent years, there is an increased number of children who are only physically active in school physical education. Physical inactivity is increasingly becoming a major public health concern in many industrialized countries (Gao et al., 2018). Research in Slovakia showed that up to 70% of school-age children and youth spend more than 4 hours of their free time a day at computers, browsing internet, watching TV, playing computer games or having fun with a phone (Antala, 2012). Afforded by technological advancement and the low demand of physical exertion in living, people in the modern societies, youth and adults alike, have been accustomed to the more sedentary lifestyles (Gao et al., 2018). The current population of children with its volume of performed physical activities approaches or even exceeds the limit, which is characterized as a biological need. The result is that inadequate physical exertion, in conjunction with the easy access to energy dense diet, has led to dramatic increases in the prevalence of obesity (Bauman, Grunseit, Rangul, & Heitmann, 2017).

The aim of the presented study was to assess relationships of physical activity to motor performance and body composition among school-age children.

Methods

Research was designed as a non-random sampling survey. The screened sample consisted of 144 students aged between 6–14 years. In order to verify hypotheses on relationships between the selected variables, the sample was further divided into sub-samples with regard to the subjects' years of study. The research group included students of the first (n=43), fifth (n=51) and eighth year of study (n=50). Characteristics of the screened sample are presented in more detail in Table 1. A participant's legal guardian received a written description of the study procedures before testing, agreed with publishing of the collected data and completed a written informed consent.

Table 1 *Descriptive characteristics of sub-groups of the research sample (average ± standard deviation)*

	Sex / no	Age (years)	Body height (cm)	Body mass (kg)	BMI (kg.m^{-2})	Body fat (%)
1st year (n=43)	B / n=26 G / n=17	7.3 ± 0.34	124.0 ± 5.8	27.2 ± 7.4	17.5 ± 3,8	22.4 ± 10.7
5th year (n=51)	B / n=25 G / n=26	11.1 ± 0.55	146.4 ± 6.8	40.5 ± 9.4	18.7 ± 3.4	22.9 ± 8.5
8th year (n=50)	B / n=16 G / n=12	14.0 ± 0.4	164.8 ± 6.9	57.6 ± 13.6	21.1 ± 4.4	21.6 ± 8.8

To record the volume of the performed physical activity, an indirect method, the self-reported Fels Physical Activity Questionnaire (Fels PAQ), which is focused on assessing the level of habitual physical activity, was used. The original questionnaire was designed without time specification. In our case, we chose a modification by Treuth, Hou, Young, & Maynard (2005), who focus on the evaluation of physical activity in an annual interval. Thus, it appropriately filters differentiations caused by different time of measurement, in terms of climatic conditions in Slovakia in contrast to the self-reported questionnaires based on evaluation over a short time period. Fels PAQ consists of eight items that include three “open” questions for which activities are listed by the participant and the frequency of participation for each activity is obtained. The remaining five questions use a Likert scale to evaluate physical activity (Treuth et al., 2005). Fels PAQ evaluates 4 fields of physical activity, namely Sport index, focused on sporting activities performed both at school and in free-time, Leisure index, evaluating extra-curricular physical activities, Chore index, assessing physical intensity of housework and, finally, Total score, which is the sum of the previous categories. According to Treuth et al. (2005), FELS PAQ achieves moderate reliability for all age groups of children and acceptable validity for monitoring PA of elementary and high schools students.

Body height was measured with a precision of 0.1 cm using a portable stadiometer (SECA 217, Hamburg, Germany). Body mass, together with the percentage of fat mass, was detected using a direct segmental multi-frequency bioelectrical impedance analysis (InBody 230 devices, Biospace Co., Ltd.; Seoul, Korea), maintaining the conditions of bioimpedance measurements (Kyle et al., 2004). The device works on the basis of ten repetitions of impedance measurement using two current frequencies, namely 20 and 100 kHz, in each of five body segments (right arm, left arm, trunk, right leg, left leg). According to Karelis, Chamberland, Aubertin-Leheudre, & Duval (2013), the In Body 230 device shows high validity of results of directly measurable body composition indicators in comparison to DEXA (r = 0.94–0.99). From the perspective of physical development, we monitored the following somatic indicators: body height, body mass and body mass index; indicators of active body mass - fat free mass and skeletal muscle mass; indicators of adipose tissue - body fat percentage.

The last evaluated category was participants’ motor performance examined in the selected motor tests. Maximum strength of upper limbs was tested in a hand grip test using Lafayette Hand Dynamometer, model 78011 (Sagamore Parkway North, Lafayette, USA). The participants were measured in the standing position with the tested arm lowered loosely at the sides of the trunk Explosive strength of lower limbs was monitored in 3 tests using Optogait device (Microgate, Via Stradivari, Bolzano, Italy) measuring the time characteristics of the contact and flight phase, based on which performance characteristics are calculated. The participants performed standardized tests of Squat Jump (SJ) and Counter Movement Jump (CMJ) according to recommendations by Markovic, Dizdar, Jukic, & Cardinale (2004). These were followed by a 10-second repeated jumps test, with the hands on hips. The power in the active phase of take-off, expressed as the mean of three best trials recorded in the given time interval, was further processed. A level of speed abilities was evaluated based on the results in linear sprints at 5 and 10 meters, according to the instructions by Malý, Zahalka, Malá, & Teplan (2014). The subjects repeated the test twice, with a rest interval of at least 2 minutes. Another parameter, speed with a change of direction, was tested using a 4 × 10 shuttle run agility test, according to Kasa (2003). Time in speed ability tests was recorded using Brower timing system (Brower Timing Systems, Draper, USA). Endurance and strength endurance were examined using the standardized Jacik's motor test (Cuberek, Jakubec, Hůlka, & Botek, 2012). The order of items in the test battery was intentionally arranged so that performances in successive tests would not be adversely affected.

The obtained data were further processed in a statistical analysis using IBM SPSS Statistics 20. Based on the results of the assessment of normality of data distribution using the Shapiro-Willk test (unpublished data), we chose nonparametric mathematical and statistical characteristics and tests for further analysis. The strength of association between the observed factors was evaluated based on the results of the Spearman's rank correlation coefficient. Results were interpreted according to magnitude presented by Hopkins (2000), when r = 0.0 represents trivial, r = 0.1 small, r = 0.3 moderate, r = 0.5 large, r = 0.7 very large, r = 0.9 nearly perfect and r = 1.0 perfect association. The significance of correlation was assessed with respect to the level of significance $p < 0.05$.

Results

Table 2 presents results of statistical analysis of the volume of performed physical activity and motor performance. Table 3 shows a matrix of results of correlation analysis between indicators of somatic development and body composition with respect to performed physical activity.

Table 2 *Results of correlation analysis of the volume of performed physical activity and motor performance (Spearman's rank correlation)*

Fels PAQ index / Jacik´s test		endurance strength / strength			speed abilities			explosive strength			
		hand grip		5 m	10 m	4 × 10 m SRAT	CMJ	SJ	10 s rep. jumps		
		d	*nd*						*P*	*h*	
1st grade	sport	**0.367***	0.184	0.116	**-0.373***	**-0.365***	**-0.456***	0.256*	0.089	0.125	0.263*
	leisure	**0.320***	**0.327***	**0.306***	-0.212	-0.193	-0.253	**0.328***	0.223	0.063	0.123
	chore	0.206	0.118	0.158	0.011	0.038	-0.040	0.082	0.148	-0.166	0.064
	total	**0.400***	0.254	0.251	-0.248	-0.208	**-0.309***	0.243	0.201	0.005	0.188
5th grade	sport	0.261*	0.085	0.066	-0.027	-0.185	-0.200	0.197	0.290*	-0.015	0.231
	leisure	0.145	-0.129	-0.075	**-0.309***	-0.212	-0.107	0.147	0.191	-0.037	0.058
	chore	0.166	0.269*	0.287*	-0.102	-0.209	**-0.354***	**0.303***	**0.312***	-0.206	0.114
	total	0.233	0.160	0.157	-0.251*	**-0.338***	**-0.344***	**0.308***	**0.359***	-0.167	0.170
8th grade	sport	0.095	**0.364***	**0.359***	**-0.397***	**-0.417***	**-0.309***	0.018	0.168	0.073	0.094
	leisure	0.182	-0.067	0.011	-0.174	-0.221	-0.288*	0.047	0.154	0.268*	0.050
	chore	-0.232	**0.438***	**0.478***	-0.273*	-0.238*	-0.081	0.061	0.133	-0.043	0.135
	total	-0.017	**0.343***	**0.395***	**-0.377***	**-0.419***	**-0.332***	0.074	0.224	0.184	0.141

Note: d – dominant hand (writing hand), nd – non-dominant hand, 5 m – linear sprint at 5 m, 10 m – linear sprint at 10 m, 4 × 10 m SRAT – 4 × 10 m shuttle run agility test, CMJ – counter movement jump, SJ – squat jump, P – power at the concentric jump phase, h – height of jump

Table 3 *Results of correlation analysis of physical activity volume and body composition parameters (Spearman´s rank correlation)*

Fels PAQ index		somatic parameters		active tissue		adiposity indicators	
BM		BMI	FFM	SMM	BFM	% BF	
1^{st} grade	sport	0.074	-0.081	**0.315***	**0.305***	-0.260	-0.016
	leisure	0.013	-0.035	0.244	0.250	-0.197	-0.005
	chore	0.099	0.087	0.080	0.089	-0.010	-0.087
	total	0.121	0.058	**0.306***	**0.308***	-0.145	-0.107
5^{th} grade	sport	-0.031	-0.016	0.040	0.044	-0.125	-0.035
	leisure	0.009	-0.085	0.104	0.101	-0.138	-0.110
	chore	-0.041	-0.041	0.004	0.006	-0.136	-0.021
	total	0.011	-0.034	0.125	0.127	-0.181	-0.034
8^{th} grade	sport	0.217	0.122	**0.402***	**0.399***	-0.093	-0.127
	leisure	-0.087	-0.182	0.122	0.118	-0.268*	-0.183
	chore	**0.320***	0.238*	**0.478***	**0.472***	-0.005	-0.199
	total	0.183	0.041	**0.462***	**0.455***	-0.219	-0.029

Note: BM – body mass; BMI Quetelet´s index; FFM – fat free mass; SMM – skeletal muscle mass; BFM – body fat mass; %BF – body fat percentage; * statistical significance of correlation

Discussion

In fact, motor skills in young children are considered to be linked with various health outcomes (Zeng et al., 2017). Physical activity may be the foundation of a healthy lifestyle and motor performance has been shown to be positively associated with physical activity in cross-sectional studies (Larsen et al. 2014). Results of the analysis of the relationship between physical activity and motor performance show the ambiguity of our findings, since across the selected age period, the strength of association differs considerably. The relationship between motor performance and the volume of performed physical activity was demonstrated only to a small extent.

In the 1^{st} year students, we found a positive moderate correlation in comparison of the results in the Jacik's test and the volume of physical activity (sport index), leisure activities and total physical activities performed. In this subgroup of participants, we also detected a moderate correlation between the hand grip test and the volume of leisure activities. In the 5^{th} year students, we only recorded low associations between strength and strength-endurance performances in relation to the values of particular Fels PAQ's indices. Moderate positive correlation was found in the 8^{th} year students between strength parameters (handgrip test) and leisure index, chore index and total score of Fels PAQ.

Moderate, but negative, correlation in this group was recorded between the amount of sporting activities and speed indicators. We believe that it could have been caused by a higher volume of exercise at a lower intensity.

In all sub-samples, results of tests focused on speed abilities and indices of physical activity have shown negative correlations. A noticeable relationship was recorded in the 1^{st} and 8^{th} year students, when moderate correlations between all three tests of speed abilities and sport index of Fels PAQ were found. In the group of 8^{th} year students, this result was also confirmed in the total score. In the group of 5^{th} year students, a moderate negative correlation was found between the total score and 10 m linear sprint test and 4 x 10 shuttle run agility test. When referred to the published results, Reed, Metzker, & Phillips (2004) and Blaes, Baquet, Fabre, Van Praagh, & Berthoin (2011) state that, not the volume, but the content of physical activities is decisive. At the same time, only a very small amount of physical activities are performed in vigorous intensity and only a low percentage of children meet the recommendations for performing physical activity.

Regarding indicators of explosive strength of lower limbs and the volume of performed physical activity, only few significant correlations between the compared pairs of data were found. In this case, they can be considered random and, thus, we can state that the relationship between the explosive strength of students of the selected age categories and the performed physical activity was not confirmed. Zeng et al. (2017) in their systematic review reported that, in 10 studies, they found an impact of physical activity on motor skills in the early childhood. In eight of them, the effect was significant. Our findings are consistent with the statement by Malina (2001) that from childhood to adolescence, the literature has generally shown a weak to moderate relationship between PA and physical performance. Similarly, a partial agreement can be noticed with findings by Larsen et al. (2014), who examined a group of children aged between 6 – 12 years in a three-year longitudinal study and concluded that motor performance has been shown to be positively associated with physical activity in cross-sectional studies. Furthermore, Wrotniak, Epstein, Dorn, Jones, & Kondilis (2006), in their study dealing with a relationship between motor proficiency, which is closely related to motor performance, and physical activity, reported that motor proficiency is positively associated with physical activity and negatively related to percentage of time in sedentary activity in children. In both studies, results of physical activity were obtained through a direct method using accelerometers, or actigraphs, respectively, which can be the reason of inconsistency with our findings. In contrast to these studies, Blaes et al. (2011) present an insignificant relationship between physical activity and motor performance in the group of 6–12 years old French children. Similarly, Reed et al. (2004) describe a weaker relationship between these variables.

Results listed in Table 3 show that physical activity is dominantly related to the active body mass. Moderate positive association was found between the parameters of the amount of muscle mass and fat free mass in relation to the sport index and total physical activity in the group of 1st year and 8th year students. Moreover, in the oldest tested group, the relationship between these parameters and chore index was detected. Pantelič & Došič (2018) reported a moderate positive correlation between Fels PAQ total physical activity and muscle mass in boys, while correlation in girls was only weak. A negative correlation between the amount of physical activity and adiposity parameters was found across all tested age categories. However, these values only achieved the level of low correlation. This is in line with a study by Dencker & Andersen (2008), who reported only low to moderate inverse relationships between moderate to vigorous PA and body fatness with a comparable population. On the contrary, study by Ness et al. (2007), who tested 11-years-old children, showed a strong negative correlation between directly measured physical activity and fat mass and obesity.

Conclusion

Since the results are ambiguous, we have to be careful in their interpretation. Firstly, because the sample was not representative and, secondly, the self-reported method of assessing physical activity can show errors. In the case of body composition, it is possible to determine the tendency between physical activity and characteristics of active body mass. Regarding the relationship between physical activity and motor performance, results are not clear. It only is possible to determine a tendency of a positive effect of the strength of upper limbs and tendency of a decreasing performance in speed tests with respect to the increase of leisure time activities. We suppose that it could be caused by a large amount physical activities performed in low to moderate intensity.

Acknowledgements

The presented data are the part of VEGA 1/0840/17 project titled „The socio-economic status and the state of infrastructure for physical activities as determinants of primary school students´ physical activity patterns and their physical and motor development".

References

Antala, B. (2012). *Telesná a športová výchova v názoroch žiakov základných a stredných škôl*. NŠC, FTVŠ UK Bratislava: END, spol. s r.o. Topolčianky.

Bauman, A. E., Grunseit, A. C., Rangul, V., & Heitmann, B. L. (2017). Physical activity, obesity and mortality: Does pattern of physical activity have stronger epidemiological associations? *BMC Public Health*, 17(1):788. doi: 10.1186/s12889-017-4806-6

Bendíková, E. (2014). Lifestyle, physical and sports education and health benefits of physical activity. *European Researcher*, 69(2-2): 343–348. doi: http://dx.doi.org/ 10.13187/issn.2219-8229

Blaes, A., Baquet, G., Fabre, C., Van Praagh, E., & Berthoin, S. (2011). Is there any relationship between physical activity level and patterns, and physical performance in children? *The international journal of behavioral nutrition and physical activity*, 8, 122. doi:10.1186/1479-5868-8-122

Cuberek, R., Jakubec, A., Hůlka, K., & Botek, M. (2012). A new view on the quality of Jacík's test. *Acta Universitatis Palackianae Olomucensis. Gymnica*, 42(2), 33–40. doi: 10.5507/ag.2012.010

Dencker, M., & Andersen, L. B. (2008). Health-related aspects of objectively measured daily physical activity in children. *Clinical physiology and functional imaging*, 28(3), 133–134. doi: 10.1111/j.1475-097X.2008.00788.x

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K., et al. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review. *Medicine and science in sports and exercise*, 48(6), 1197–1222. doi: 10.1249/MSS.0000000000000901

Gao, Z., Chen, S., Sun, H., Wen, X., & Xiang, P. (2018). Physical Activity in Children's Health and Cognition. *BioMed Research International*, 2018, 1–4. 10.1155/2018/8542403

Hopkins, W. G. (n.d.). (2000). *A New View of Statistics.* Retrieved April 5, 2020, from https://www.sportsci.org/resource/stats/effectmag.html

Karelis, A. D., Chamberland, G., Aubertin-Leheudre, M., & Duval, C. (2013). Ecological mobility in Aging and Parkinson (EMAP) group. Validation of a portable bioelectrical impedance analyzer for the assessment of body composition. *Applied physiology, nutrition, and metabolism,* 38(1), 27–32. doi: 10.1139/apnm-2012-0129

Kasa, J. (2003). *Diagnostika pohybových predpokladov v športe*. Trenčín: Trenčianska univerzita Alexandra Dubčeka v Trenčíne, Ústav prírodných a humanitných vied.

King, G., Law, M., King, S., Rosenbaum, P., Kertoy, M. K., & Young, N. L. (2003). A conceptual model of the factors affecting the recre-ation and leisure participation of children with disabilities. *Physical and occupational therapy in pediatrics*, 23(1), 63–90.

Kyle, U. G., Bosaeus, I., De Lorenzo, A. D., Deurenberg, P., Elia, M., Gomez, J. M., et al. (2004) Bioelectrical impedance analysis-part I: review of principles and methods. *Clinical nutrition*, 23(5), 1226–43. doi: 10.1016/j.clnu.2004.06.004

Larsen, L. R., Kristensen, P. L., Junge, T., Rexen, C. T., & Wedderkopp, N. (2015). Motor Performance as Predictor of Physical Activity in Children: The CHAMPS Study-DK. *Medicine and science in sports and exercise,* 47(9), 1849–1856. doi: 10.1249/MSS.0000000000000604

Malina, R. M. (2001). Adherence to physical activity from childhood to adulthood: a perspective from tracking studies. *Quest*, 53(3), 346–355. doi: 10.1080/00336297.2001.10491751

Malý, T., Zahalka, F., Malá, L., & Teplan, J. (2014). Profile, correlation and structure of speed in youth elite soccer players. *Journal of human kinetics*, 40, 149–159. doi: 10.2478/hukin-2014-0017

Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *Journal of strength and conditioning research*, 18(3), 551–555. doi: 10.1519/1533-4287(2004)18<551:RAFVOS>2.0.CO;2

Morrison, K. M., Bugge, A., El-Naaman, B., Eisenmann, J. C., Froberg, K., Pfeiffer, K. A., & Andersen, L. B. (2012). Inter-Relationships Among Physical Activity, Body Fat, and Motor Performance in 6-to 8-Year-Old Danish Children. *Pediatric exercise science*, 24(2), 199-209. doi: 10.1123/pes.24.2.199

Ness, A.R., Leary, S.D., Mattocks, C., Blair, S.N., Reilly, J.J., Wells, J.C., Ingle, S., et al. (2007). Objectively Measured Physical Activity and Fat Mass in a Large Cohort of Children. *PLoS Medicine*, 4(3), 1136–1138. doi: 10.1371/journal.pmed.0040097

Pantelić, S., & Đošić, A. (2018). The relations between physical activity and body composition of school-age children*. FACTA UNIVERSITATIS Series: Teaching, Learning and Teacher Education*, 2(2), 137–147.

Reed, J. A., Metzker, A., & Phillips, D. A. (2004). Relationship between physical activity and motor skills in middle school children. *Perceptual and motor skills,* 99(2),483–494. doi: 10.2466/pms.99.2.483-494

Treuth, M., Hou, S. N., Young, D. R., & Maynard, A. M. (2005). Validity and Reliability of the Fels Physical Activity Questionnaire for Children. *Medicine and science in sports and exercise*, 37(3), 488–495. doi: 10.1249/01.mss.0000155392.75790.83

Wrotniak, B. H., Epstein, L. H., Dorn, J. M., Jones, K. E., & Kondilis, V. A. (2006). The relationship between motor proficiency and physical activity in children. *Pediatrics*, 118(6), 1758–1765. doi: https://doi.org/10.1542/peds.2006-0742

Zapletalová, L., Antala, B., Doležajová, L., Labudová, J., & Lednický, A. (2011). *Sekulárny trend v ukazovateľoch telesného rozvoja a po-hybovej* výkonnosti 11- až 18-ročnej školskej populácie na Slovensku. Peter Mačura – PEEM.

Zeng, N., Ayyub, M., Sun, H., Wen, X., Xiang, P., & Gao, Z. (2017). Effects of Physical Activity on Motor Skills and Cognitive Development in Early Childhood: A Systematic Review. *BioMed Research International*, 2017, 1–13. https://doi.org/10.1155/2017/2760716