INTENSITY OF SOCCER PLAYERS´ TRAINING LOAD IN SMALL-SIDED GAMES WITH DIFFERENT RULE MODIFICATIONS

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Nikolas Nagy, Miroslav Holienka, Matej Babic

Faculty of Physical Education and Sport, Comenius University in Bratislava, Slovak Republic

ABSTRACT

Purpose: The aim of this research was to make reference to the difference in heart rate values (HR) of soccer players in small-sided games (SSG) with different rule modifications. We assumed that the permitted number of ball touches in SSGs will significantly affect the internal load of participating soccer players' organism.
Methods: The experimental group consisted of older junior players (U19) from the FC DAC 1904 Dunajská Streda soccer club (n=6). The HR values were evaluated on the basis of collected data, which were obtained using sport testers and special software. In order to find out the statistical significance of the difference in HR the one-way ANOVA and the Bonferroni post hoc test was used. The level of statistical significance was set at 5%.
Results: We found out that by the change of the SSG rules, the internal reaction of players´ organism to training load was at different level. In the SSG1, where players were permitted only one ball contact during the SSG, the highest achieved average HR value of the monitored players' (160.08 ± 9.27 beats.min^{-1}) was recorded. This form of the SSGs was the most intense for the players' cardiovascular system. However, there were no significant differences in HR values among the different types of the SSGs.
Conclusions: Our recommendation is to employ small forms of SSGs (3 vs. 3) with different rule modifications in the systematic training process, because by the means of it we can adequately prepare the players for the real competitive match demands.

Keywords: soccer; training load; heart rate; rule modifications; small-sided games

Introduction

The constant development of contemporary soccer is also influenced by the quality of the systematic, long-term premediated and purposeful training process. Properly increasing the level of the training process brings about important questions for soccer coaches, including the appropriate optimization and suitable intensification of soccer players´ training load. In the mindfully designed training units of soccer players have an inevitable role the realization of small-sided games (SSG) with different modifications. During SSGs, it is possible to progressively raise the level of skill potential, tactical behaviour, fitness capacity and emotional intelligence of soccer players. Throughout the SSGs players need to solve a lot of variously complicated and complex game situations during time-space deficiency under active pressure of defensive player. The conditions in various forms of SSGs are really close to the competitive match conditions.

The aim of systematic training process is to help increase the adaptation capacity of player´s organism to the load, with which players are closely confronted in the game itself, or more precisely in the real match (Holienka, 2004). The training process need to focus on the creation of a specific adaptation change in the player´s organism, which is induced by purposeful repeated adaptation stimuli (Holienka, 2012). When the batching of training stimuli is proper, it contributes to the development, progressive increasing, stabilization and preservation of the training experience state, then can we note about the meaningful training load (Kačáni, 2005).

Holienka (2012) states that indicators of internal load, including the values of heart rate (HR), make it possible to determine the usefulness and effective level of training load during training units. These modern devices provide accurate feedback on actual reactions of the internal state of players´ organism to the training load. The HR values are widely accepted and frequently used physiological indicator of the players´ physical activity in the training units (Holienka, 2016). Nowadays the monitoring of HR become an inseparable part of the training load research in collective sports, such as in soccer, and many authors dealt with this issue in their research (Dellal et al., 2008; Halouani et al., 2014a; Randers et al., 2014; Köklü et al., 2015; Asci, 2016; Proietti et al., 2017; Babic & Holienka, 2018).

Sport testers give us immediate feedback on the reaction of player´s organism to the load (Benson & Connolly, 2012). Monitoring of HR values is to a large extent implemented in training units, which include different variations of SSGs. It is also widely used in youth soccer to gain and understand the physiological parameters of training units and real match load in different levels (Owen, 2016).

Holienka (1998) claims that the current required principle in systematic soccer training process – all with a ball – fulfills the game training (GT). The dominant position in it have different forms of SSGs, which include a wide range of situation that are similar to the real game situations during a competitive match. Systematic training activity of soccer players in sports games, like soccer should take into consideration the specific technical, tactical, physiological and psychological demands of individual game performance (Christopher et al., 2016; Zapletalová et al., 2017). Therefore, different variants of SSGs have become a favourite and necessary part of the training unit when we want to increase the level of game preparedness and fitness capacity of players. By applying the principle of “adequate coverage theory”, we try to model in the training process through SSGs such game conditions, which are very similar to real match conditions. Ideally, the training unit has to contain such SSGs, where the physiological curve moves at the level or above of the anaerobic threshold (ANT).

Soccer coaches are able to influence the intensity of the training load in SSGs if they adequately manipulate with the variables, which affect the intensity of SSGs.

Among these variables we can mention: the number of players, the size of playing field, coaching methods, game rules, content focus of the game, goal size, number of goals, presence of goalkeepers, dosing of work : rest intervals and different rule modifications, like the number of ball touches (Aktas et al., 2014; Halouani et al. 2014b; Gonzáles-Rodenas et al., 2015; Torres-Ronda et al., 2015; Holienka, 2016; Brandes et al., 2017; Giménez et al., 2018; Mikulič et al., 2018; Nagy & Holienka, 2018; Peráček et al., 2018a, 2018b; Nagy & Babic, 2019).

Knowing that the number of ball contacts could affect the physiological responses and, therefore, the potential beneficial effect for individual and team performance improvement, it has to be noted how permitted 1 ball touch, 3 ball contacts and the free number of ball touches to affect the internal load during SSGs.

Thus, the main aim of the present study was to compare the effects of 3 variants of SSGs with different rule modifications, especially the number of ball contacts. These 3 forms of SSGs with limited and unlimited ball touches are indeed very popular and much used by soccer coaches during training sessions. The findings could potentially provide valuable, reliable and useful information to coaches for the design different forms of SSGs as part of their training process.

Methods

Experimental approach to the problem

In our research we measured internal load (cardiovascular response) during three different forms of 3 vs. 3 SSGs. SSGs were played with the same team consist of 3 players against the same opposite team for each of the 3 SSG variants, and only the number of permitted ball touches were changed among SSGs. This approach allowed us to identify the changes in the rule modifications mentioned earlier.

The dependent variable was the internal load of players´ organism, expressed by the level of HR, and the independent variable was the permitted number of ball contacts/player during the SSGs.

Participants

The research group consist of six (n=6) male youth soccer players (aged 17.8 ± 0.7 years, body mass 68.5 ± 6.1 kg, body height 176.6 ± 5.5 cm, VO_{2max} 61.06 ± 3.24 $ml.min^{-1}.kg^{-1}$, maximum heart rate (HR_{max}) 199.8 ± 7.6 $beats.min^{-1}$) from the FC DAC 1904 Dunajská Streda U19 soccer club. The monitored players were participants at the highest competition of this age category in Slovakia (1.LSD).

Methods of measurement

One of the main methods to acquire the data used during this research was HR measurement. First of all, we ascertained the values of maximum heart rate (HR_{max}). The HR_{max} was calculated using a field test by Hipp (2007). During testing the tested soccer player had to run 50 meters in a defined area, which they completed with various intensities. The test included 6 repetitions in every single set of the run. Players went through 4 sets and in each one of them the intensity was gradually increased to the maximal subjective intensity.

The test included:

- low-intensity run (warm-up): 120–130 BPM – 6 times,
- medium intensity run: 130–150 BPM – 6 times,
- submaximal intensity run: 150–170 BPM – 6 times,
- maximum (subjective) intensity run – once.

There was a 30 seconds rest interval between the repetitions and 60 seconds between the sets. According to the maximum heart rate (HR_{max}) we determined 5 load zones.

Table 1 *Intensity load zones according to the HR values (Moravec et al., 2007)*

ZONE	% HR_{max}	CHARACTER
Zone 1	50–59%	Very low intensity
Zone 2	60–69%	Low intensity
Zone 3	70–79%	Medium intensity
Zone 4	80–89%	Submaximal intensity
Zone 5	90–100%	Maximal intensity

To measure the HR the set of sports testers POLAR TEAM was used. The calculation of the percentage and time representation of HR values was done by using a special program and software.

Small-sided games (SSGs)

Game description:

Players played the SSGs in a defined area with permitted one, three and unlimited number of ball contacts. They could pass the ball between themselves any times. After scoring the goal, the game was started by the goalkeeper, whose team scored the goal.

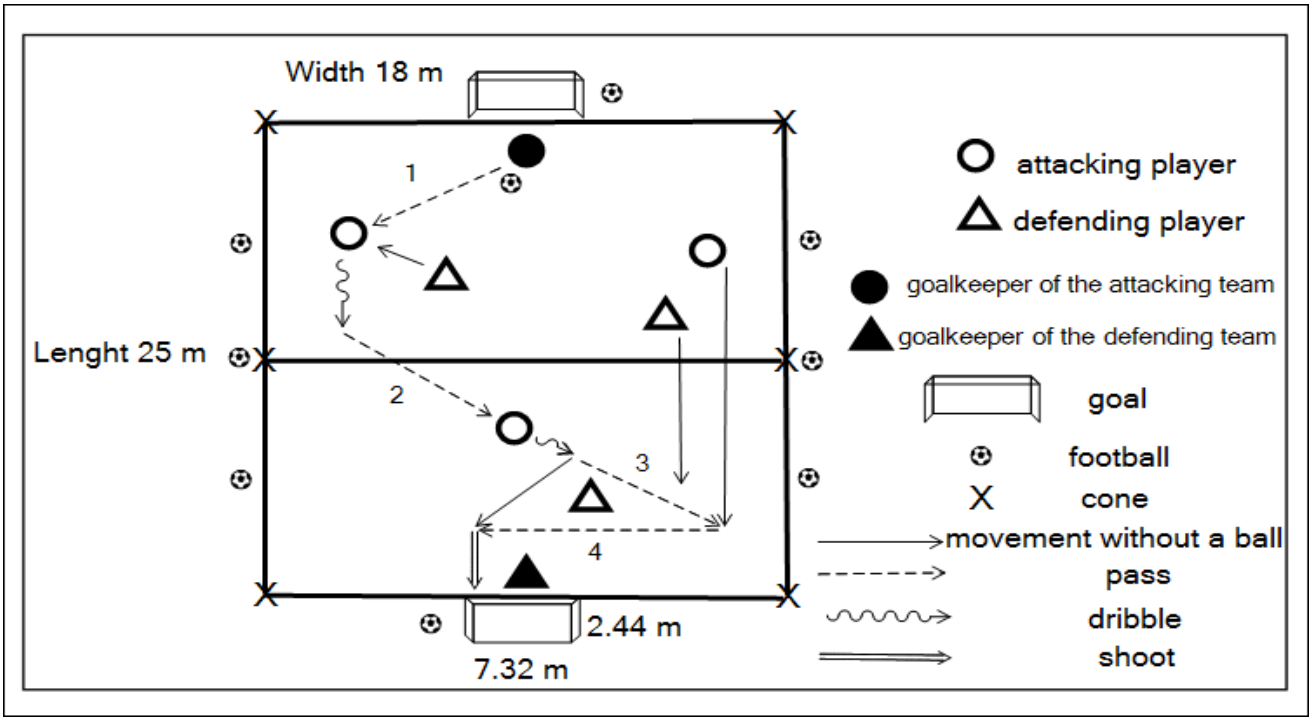

Figure 1 *SSG*

During SSG1 players must play with one permitted ball contact. In SSG2 players had 3 permitted ball touches. Throughout SSG3 players had unlimited ball contacts, they played on free manner. During the SSGs the number of repetitions was 4, the work interval (WI) lasted 2 minutes, the rest interval (RI) was in each variants 2 minutes. The work and rest ratio were 1 : 1.

Table 2 *Different forms of SSGs*

SSG	Number of ball touches	Players	GKs	Field dimensions		Field area	Area/ player	Batch load				
		(n = 6)	(n = 2)	Width [m]	Length [m]	[m²]	[m²]	WI [min.]	RI [min.]	NR	NS	L [min.]
SSG1	1	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16
SSG2	3	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16
SSG3	free	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16

Statistical analysis

To determine the statistical significance of the HR values the One-Way ANOVA method and Bonferroni post hoc test was used. The level of statistical significance was set at 5% ($p < 0.05$). The results were interpreted, compared and we also tried to find the connections between them. On the basis of these data, we formulated conclusions and recommendations for the sport theory and to training practice.

Results

The monitored players spent during SSGs with different rule variations in selected intensity load zones different time. In table 3 the average time values and the percentage representation of players´ remaining in each intensity load zone are presented.

Table 3 *Remaining of players in each load intensity zone*

Load zones	50–59% HR_{max}		60–69% HR_{max}		70–79% HR_{max}		80–89% HR_{max}		90–100% HR_{max}	
Intensity	**Very low**		**Low**		**Medium**		**Submaximal**		**Maximal**	
SSG	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**
SSG1	0.34	3.51	2.19	16.51	3.11	19.26	4.48	31.46	5.06	34.28
SSG2	1.02	6.28	2.51	19.36	3.43	24.87	4.13	26.12	4.51	29.75
SSG3	1.41	10.26	3.29	24.62	2.51	17.61	5.13	32.25	2.57	18.26

The highest intensity of the training load was monitored during SSG1, in which the players had to play with one ball contact, they were limited with one ball touch. Players remained in the SSG1 the longest time period in the maximal intensity load zone (90–100% HR_{max}) on average 5.06 minutes (34.28%) of SSG1 duration. In this form of SSG players spent least time in very low intensity zone (50–59% HR_{max}). In this zone the players remained even for half a minute. The lowest intensity was monitored in the SSG3, where the players had unlimited ball contacts and could play in free manner. On average players spent 2.57 minutes (18.26%) of the SSG3 duration in the load zone of maximal intensity. In SSG2, where participants had maximal 3 ball touches the players spent 4.51 minutes (29.75%) of the SSG2´s total time in the load zone of maximal intensity. The highest average value in the load zone of medium intensity represented was during SSG2, 3.43 minutes, (24.87%).In the SSG3 the players remained the most time in the load zone of submaximal intensity (80–89% HR_{max}), on average 5.13 min. (32.25%). In the load zone of low intensity players spent the most time in SSG3 too.

The internal response of organism with different rule modifications was monitored using the HR values. The recorded values are stated in Figure 5.

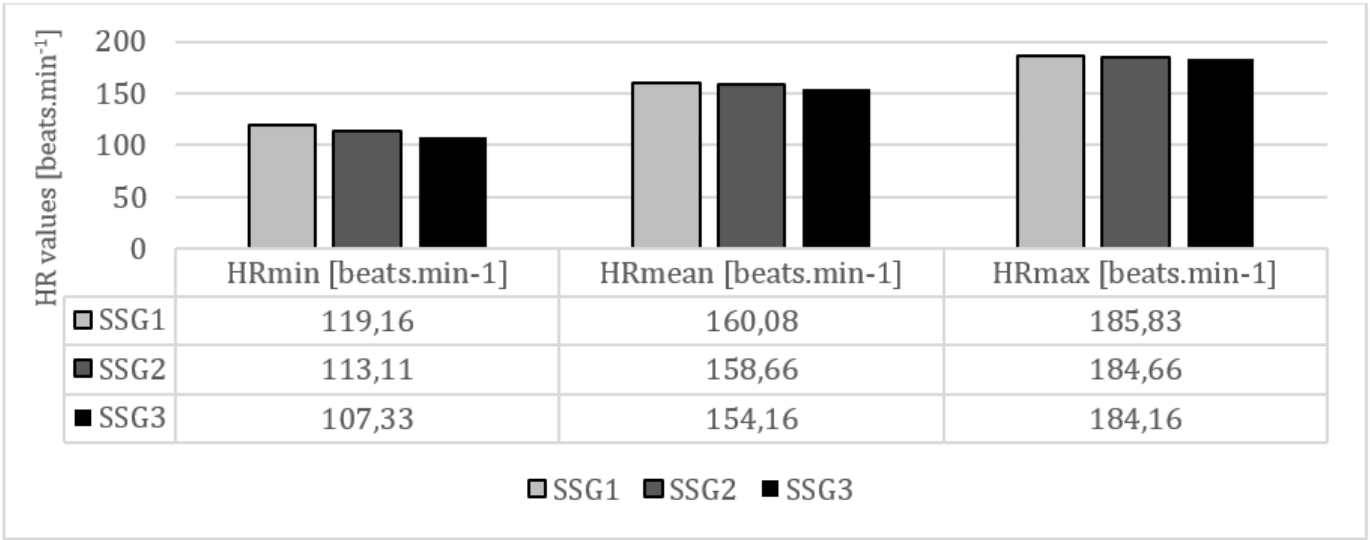

Figure 2 *The average HR values in different SSG forms*

The highest average value of minimum HR (HR_{min}) was achieved by the monitored players in the SSG1, where players had only one permitted ball contact, 119.16 ± 12.48 beats.min^{-1}. The lowest values were monitored in the SSG3, where players had unlimited ball touches, 107.33 ± 12.12 beats.min^{-1}. In the SSG2 with maximal 3 ball contacts were the HR_{min} 113.83 ± 9.31 beats.min^{-1}.

The mean HR values (HR_{mean}) of the monitored players was the lowest in the SSG3 154.16 ± 8.25 beats.min^{-1} and the highest in the SSG1 160.08 ± 9.27 beats.min^{-1}. In the SSG2 we measured 158.66 ± 8.09 beats.min^{-1}.

The recorded average value of maximal HR (HR_{max}) was the lowest in the SSG3 184.16 ± 7.02 beats.min^{-1} and the highest in SSG1 185.83 ± 9.06 beats.min^{-1}, in the SSG2 was recorded HR_{max}184.66 ± 5.75 beats.min^{-1}.

In small forms of the SSG, in which the players played 3 vs. 3, the training load was often higher than the real match load itself. The recorded ascertained values of HR_{max} show that players performed the training activity at a high level. Differences between the ascertained HR_{max} values and percentage values from HR_{max} (Tab. 4) are at a low level. We can see that the highest value was in the SSG1 (92.66%) and the lowest in the SSG3 (91.83%).

Table 4 *Values of HR_{max} and % of HR_{max} during the different SSG variations*

SSG	HR_{max}		% HR_{max}	
	[beats.min^{-1}]	SD	[%]	SD
SSG1	185.83	9.06	92.66	4.67
SSG2	184.66	5.75	92.16	3.18
SSG3	184.16	7.02	91.83	2.22

In contemporary soccer the match load is at the level of the anaerobic threshold (ANT). During the training process in different forms of SSGs the training load is at a higher level. In this case time spent above the ANT represents higher values.

Table 5 *Time spent above the ANT*

SSG	Time spent above the ANT	
	[min]	[%]
SSG1	6.23	38.11
SSG2	5.32	34.06
SSG3	4.58	32.15

Players spent the most time above the ANT in the SSG1, it was up to 6.23 minutes (38.11%) of SSG1 duration and at least in the SSG3 4.58 minutes (32.15%) of the SSG´s total time. In the SSG2 the time spent above the ANT was 5.32 min, which represents up to 34.06% of the SSG.

On the basis of the One-Way ANOVA results, we can state that there is a statistically insignificant difference in mean HR values after completing the SSGs with different rule modifications ($F = 0.7657$, $p = 0.4824$).

The statistical significance between the SSG1 and SSG2 was not proved ($t = 0.2699$, N. S.). The difference between the HR_{mean} was only 1.42 beats.min^{-1}. It was probably caused by the fact that the change of permitted number of one ball contact/player or three touches to the ball in SSGs did not significantly influence the internal response of players' organism, and therefore, the average values of HR were not different.

Between the SSG1 and SSG3 no statistically significant lower HR_{mean} values ($t = 1.1808$, N. S.) were found. In the SSG1 the HR_{mean} values were 160.08 ± 9.27 beats.min^{-1}, in the SSG3 HR_{mean} values of 5.92 beats.min^{-1} less, 154.16 ± 8.25 beats.min^{-1} were recorded.

Statistically significant differences in the HR_{mean} values between the SSG2 and SSG3 were not proved ($t = 0.9109$, N. S). The difference between the HR_{mean} values was 4.5 beats.min^{-1}. The rule modifications in SSGs did not significantly affect the internal response of the players´ organism during the game.

Discussion

The main aim of the present study was to compare the cardiovascular response in 3 different SSGs forms. Thus, 3 SSG variants, with identical number of players (3 vs. 3), pitch dimensions (18 × 5 m), same number of sets, reps, work and rest ratio (1 : 1), but different in the permitted number of ball contacts (SSG1- 1 touch, SSG2- maximal 3 ball touches, SSG3-unlimited ball contacts/player) were compared.

We purposely choose small form of SSG when the players‘ perform with a number of 3 vs. 3, in a tight area (75 m^2/player), because players need to solve various game situations under time-space deficit like in competitive match play.

HR is a generally accepted and often used physiological indicator of the players´ physical activity in the training process (Holienka & Cihová, 2016). When speaking about the results obtained from the sports devices, one has to respect the fact that the HR values showing the training load intensity of the soccer players´ organism in different forms of SSGs are only indirect indicator.

Different forms of SSGs in a systematic training process enable the players to improve and stabilize the technical and tactical side of game activities, to secure the development of creative thinking and their actions on soccer pitch. SSGs with different rule modifications ensure the realization of individual´s game activities and combinations, which have a positive effect on spatial orientation, physical activity and players´ emotions as well.

In training practice, soccer coaches quite often modify playing rules in different forms of SSGs to achieve greater exercise intensity or develop soccer specific technical and tactical skills. Rule changes increase the cognitive load required from players as a consequence of new rules (Hill-Haas et al., 2011).

Los Arcos et al. (2015) claims that the SSGs are more effective to improve and maintain the aerobic capacity of young soccer players´ than interval training. Players during the SSGs showed more joy in physical activity than during the interval training.

Through the SSGs it is possible to maintain the level of anaerobic abilities by specific means and to increase the players´ motivation. The SSGs performed on smaller playing fields, in which is involved a lower number of players, are ideal for development and improvement of special match condition and game capacity (Peráček et al., 2018a; Mikulič et al., 2018).

Small forms of SSGs (3 vs. 3 players) represent for coaches an alternative to increase the demands on the cardiovascular and metabolic system of young players (Halouani et al., 2017). The HR values in the SSG1, where players had permitted only one ball contact, were higher than in the SSG2, in which players had allowed maximal three ball touches, or in the SSG3, where players had unlimited ball contacts.

Castellano et al. (2013) claim that the intensity of the training load was highest in the SSG with a focus on ball holding, with unlimited ball contacts. In our case, in SSG1 were measured the highest HR values, when players need to solve game situations with one ball contact. This can be due to the fact that the players have to constantly work with the space, free themselves of the opponent and adequately make a free space for their teammates. Players' tried to use goalkeepers often, because they could cooperate with him, especially in SSG1.

In Table 6 is presented the internal response of the players´ organism to the match load according to Mendez-Villaneuva et al. (2013) in the U18 age category. The zones of load intensity were divided at the same level as in our research. The intensity of the training load was on the same level than the match load. In some cases, especially in SSG1 we measured a little higher intensity load than the real match conditions. We need to consider, that in our research the work interval was 2 minutes and the rest interval lasted 2 minutes too. It was ideal to prepare players to be match fit and game ready.

Table 6 *Intensity of U18 players´ match load (Mendez-Villaneuva et al., 2013)*

Zones	< 60% HR_{max}		61–70% HR_{max}		71–80% HR_{max}		81–90% HR_{max}		91–100% HR_{max}	
Match	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
[%]	2.8 ± 5.8	1.0 ± 1.6	6.6 ± 6.6	8.5 ± 5.7	17.3 ± 9.6	26.5 ± 9.9	36.7 ± 13.3	40.8 ± 8.1	36.5 ± 22.8	22.6 ± 14.4

During the soccer match the internal response of the players' organism to the load is in different levels. A systematic, purposefully thought-out training process has to stimulate those bio-energy systems, which predominate in the real match conditions. In training practice this criterion replaced with the cognition and adequate manipulation of SSG variables, including the rule modification (Peráček, 2014).

Švihorík (2005) claims that, when concerning the SSG rules, it is necessary to be mindfully prepared and preventing from the frequent interruption of SSG continuity. These rules should force the players to play and move all the time.

In the SSG1 the players had only one permitted ball contact. It was very challenging without adequate space selection, movement without the ball, physical activity, etc... The ball often got outside the playing field. Although the replacement balls were prepared around the playing field, so the players could keep the HR values and intensity of play at a high level. In SSG2 and SSG3, where players had permitted more ball contacts, the game quality was much more better.

Coelho et al. (2016) found that the players spent a statistically significant more time above the ANT level in the first half of the match than in the second half. By using small forms of the SSGs with the number of players 3 vs. 3, it is possible for us to prepare the players for the real match load intensity, like in our study with SSG1.

Table 7 *Comparison of the mean HR values during soccer matches*

AUTHOR (YEAR)	**AVERAGE HR [beats/min]**	**TYPE OF MATCH**
Florida-James & Reilly (1995)	165	competitive
Thatcher & Batterham (2004)	166	competitive
Helgerud et al. (2001)	171	competitive
Capranica (2001)	180	competitive
Krustrup (2006)	156	pre-season
Reilly (1996)	157	pre-season
Seliger (1968)	165	pre-season
Van Gool et al. (1988)	166	pre-season

The mean HR values found in different forms of SSGs are at a similar level to the values recorded in competitive or pre-season matches at different levels and with various age categories (Seliger, 1968; Van Gool et al., 1988; Florida-James & Reilly, 1995; Reilly, 1996; Capranica, 2001; Helgerud et al., 2001; Thatcher & Batterham, 2004; Krustrup, 2006).

Conclusions

The purposeful use of modern technologies in training units, such as sport testers, enable the sports experts or coaches to find out the internal response of the players´ organism to the intensity load and get objective feedback on the adequacy of the training load.

In this research our aim was to point out to the cardiovascular reaction of the players´ organism during SSGs with different number of permitted ball contacts/player. On the basis of acquired data, we can state that in the SSGs with various rule modifications the average HR values were at different level. The highest HR values were recorded during SSG1, where players had allowed only one ball contact. Players in this type of SSG remained the longest time in the load zone of maximal intensity and spent the most time above the ANT. For this reason we can claim that the SSG1 was the most intense one from these three versions.

Recommendations for didactic theory and training practice

On the basis of our findings in this research, we can state that by the change of the rules in SSGs, it is possible to increase, but also decrease the demands on individual bio-energy systems of the players´ organism.

Our recommendation is to integrate all 3 different variants of SSGs into the systematic training process, depending on players' technical capability. During SSG1 with only one permitted ball contact/player the intensity was high but there were a lot of lost balls and inaccuracy. For some players with low level of technical-tactical preparedness solving game situations adequately proved to be hard. During SSG2 with 2 permitted ball touches/player the intensity was on a lower level, but the quality of the game was much better. The difference between HR_{mean} was 2.14 beats.min^{-1}. Three allowed ball touches/player during SSG3 ensured that players have time to receive the ball, analyse the game situation and solve it correctly, but in that case the intensity level was on lower rate.

We found out that the optimization and intensification of the training load in the SSG can also be adjusted by rule modifications. During SSGs the HR values were at the same level as the match load level, so we can state that during SSG1 and SSG2 we can prepare players for real and competitive match demands.

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