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Original Article

Internal load of soccer goalkeepers during the improvement of selected game activities

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Abstract:
The main topic of our research was to determine the internal load of goalkeepers in the phase of improving game activities. We focused on the analysis of the achieved heart rate values. In this way, we wanted to extend the knowledge of the impact of the various small sided games (SSG) on the internal load on soccer goalkeepers, there by supporting the effort to improve the youth training process. We assumed the goalkeepers reached a significantly different level of heart rate, terms of their individual assumptions and load variability in different small sided games. Four goalkeeper´s (U16, U17) internal load were analysed by POLAR Team PRO. To determine statistical significance, we used the Wilcoxon T-test. Then we calculated Cohen r (effect size) and the significance test of two relative values. The selected level of statistical significance was $p \leq 0.05$. We found different mean heart rate values in selected small sided games, so we confirmed the assumption at least logically. At the same time, we confirmed that both small sided games had the required impact on adaptive changes to the goalkeeper´s body.
Keywords: soccer, goalkeeper, internal load, heart rate, sporttester.

Introduction

The trainer has to fully know his goalkeeper and build the contents of the training units in accordance with his personality. For this reason, it is necessary to look for new approaches to the planning of specialized goalkeeper training (Smith 2004, Plachý 2007). Youth goalkeeper trainers should strive to constantly educate themselves and optimize the structure of the specialized training process in such a way so as to prepare young goalkeepers for soccer of the future (Ruiz 2003).

And thus, when constructing a young goalkeeper's sports preparatory, the trainer should take into account the developmental tendencies in soccer and the sensitive developmental periods of individual physical abilities (Hrnčiarik 2012, Peráček et al. 2017). Furthermore, training must be clearly focused on the requirements of the match, which determines the goals and content of individual components of sports training (Barry 2009). There is only one proven way for the goalkeeper to improve, and that is through quality regular and specialized training (Gustafsson and Janson 1997). A similar issue was dealt by Montesano (2016), who found significant improvement in goalkeeper´s performance through specialized training.

Training processes lead to summation of individual training stimuli that are inflicted upon the player's organism. When the stimuli are given so that they have a training effect, i.e. they contribute to developing or maintaining the status of being in training, we are talking about the training load. Depending on the size of the training load, changes occur in the player's body, gradually adapting to the increasing burden (Holienka and Lednický 2000). The heart rate (HR) is a generally recognized and widely used objective physiological indicator of the player's motion activity in the training process, or, where possible, even in the match (Holienka 2016).

The division of heart rate into training zones is essential for the management of sport training, its individualization, efficiency and effectiveness in achieving the intended goal (Olšák 1997).

Vencel (2013) found, during an analysis of a match played between younger adolescents that the goalkeeper's heart rate in the match was more responsive to emotions than to the burden of short sprints that arose from situations within the match. The maximum heart rate in the game went up to 181 BPM and the average heart rate was 143 BPM. For comparison, Espaňa (2012) measured average values of the goalkeeper's heart rate during the match to be only 128 BPM. According to Peráček et al. (2004), application of methodical forms in didactic process of different arrangements of external conditions and the content of the didactic process enable the fulfilment of tasks related to the practice and improvement of game activities. The application of methodical forms in the didactic process is very closely related to the internal and external load of the player, namely with one of its components - complexity.

According to Holienka (1999), appropriate changes to the rules and the content of small sided games as one of the methodical forms, are important to fulfil the accepted training goals and tasks.

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In small sided games, with regard to the age and performance category of the players, we can manipulate:

- the play area,
- the number of players,
- changing rules,
- load interval and rest interval,
- the number of repetitions.

Small sided games are associated with the effectiveness of the training process for the player's game performance (Clemente et al., 2012, Michailidis 2013, Benkovský et al., 2016). Pakusza and Tarkovič (2002) state in their work that small sided games, thanks to their variability, diversity, and situational unpredictability, create ideal conditions for the complex development of gaming capability. Based on our own knowledge of player activity and coaching, we can also confirm this in regards to the goalkeeper position.

Material and method

The aim of the research is to broaden the knowledge of the functional responses of soccer goalkeepers in the stage of improving game activities in younger adolescents.

We expect a significantly different level of heart rate for goalkeepers in terms of their individual conditions and the variability of the load distribution in the small sided games.

The following tasks have emerged from the set goal:

1. Select and build appropriate types of small sided games to improve game activities in goalkeepers' training.
2. Determine the functional responses of the goalkeeper body to the load in the small sided games using sporttesters.
3. Evaluate and compare the results obtained from the internal load of goalkeepers in small sided games based on physiological curves.

The research team consisted of four goalkeepers of ŠK Slovan Bratislava in the category under 16 and under 17 years. The goalkeepers are members of teams which are participants of the Slovak National Junior League of younger boys. The age average of watched goalkeepers was 15,25±0,5 years at the time of the survey. Club ŠK Slovan Bratislava has the status of the Football Academy (FA). The training process of goalkeepers represents 5 training units per week. The main method of obtaining research data was to measure the heart rate (HR) of the monitored goalkeepers using sporttesters. We used the POLAR PRO sporttesters for the measurements. The maximum heart rate of goalkeepers was determined using the test by Hipp (2007). The point lies in repeated stretches of running done in such a way that the basic slow trot gradually increases in speed up to a point of individual maximum intensity.

The test includes:

Running the width of the playground

- low intensity run (warm-up) 6 times,
- medium intensity run 6 times,
- submaximal intensity run 6 times,
- maximum (subjective) intensity run 1 time.

Based on the ascertained maximum heart rates, POLAR Team PRO calculated the training zones for every goalkeeper. These zones and their division significantly affect the management, individualization, and effectiveness of the training process.

We used to process and evaluate the data calculation of the percentage and time representation of heart rate values in individual zones by the special program POLAR Team PRO. To determine statistical significance, we used the Wilcoxon T-test. Then we calculated Cohen r (effect size) and the significance test of two relative values. The selected level of statistical significance was $p \leq 0.05$. We compared the obtained results, found connections between them and based on them we made recommendations for training practice.

Results

In research, we decided to monitor the organism's functional response to two selected small sided games. All four goalkeepers were being monitored in both games.

Small sided game 1

Number of players: 2:2 *Playing field*: 22x18 m
Load interval (LI): 2´ *Rest interval (RI)*: 2´
Number of repetitions (NR): 4 *Number of series (NS)*: 1
Focus: improving the game activities – catching, playing by foot, 1:1 situations
Game description and game rules: Goalkeepers play for a free amount of touches in the designated area. Both goalkeepers are allowed to grab the ball with their hands on their own half of the field. After a goal is scored, the pair who received the goal begins. If the ball reaches past a lateral line, the out throwing is kicked instead. If the ball reaches past the goal line and is to be followed by a corner kick, the ball goes to the pair which was to have the corner kick. The pair then starts from its own gate.

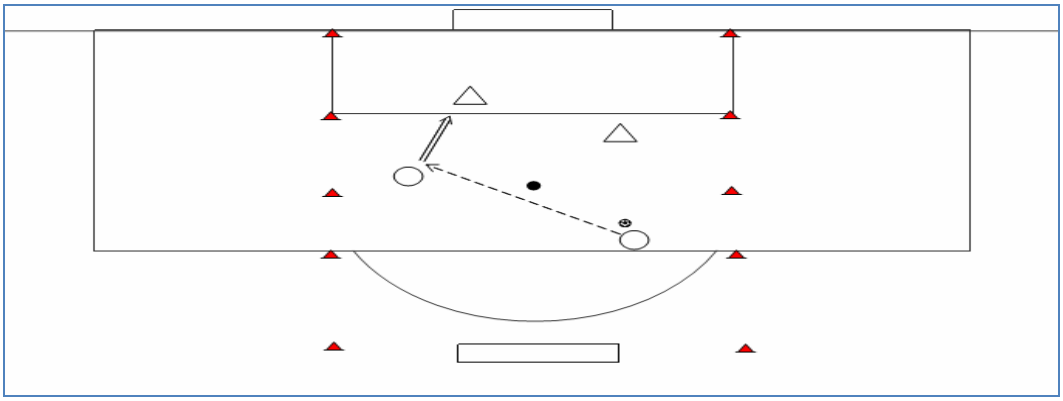

Fig. 1. Small sided game 1

Small sided game 2

Number of players: 2:2 *Playing field*: 22x18 m
Load interval (LI): 2´ *Rest interval (RI)*: 2´
Number of repetitions (NR): 4 *Number of series (NS)*: 1
Focus: improving the game activities – catching, playing by foot, build-up attack
Game description and game rules: Goalkeepers alternate finishing moves (leg from the ground, volley, hand, etc.) at their opponent's goal from their own zone. After a goal is scored, the pair who received the goal starts. If the ball leaves the goal line and is to be followed by a corner kick, the ball again goes to the pair who was to have the corner kick. If the goalkeeper misses the goal, he will do two quick jumping squats and the ball will be transferred to the opponent.

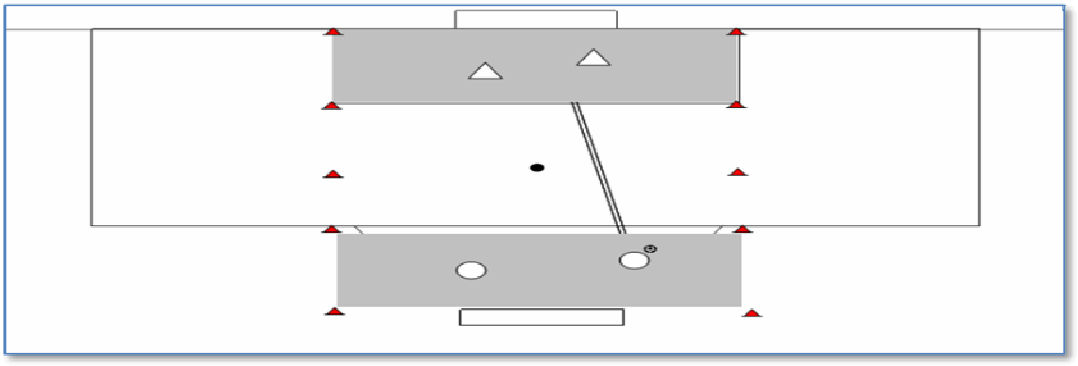

Fig .2. Small sided game 2

Functional responses of the goalkeeper´s organisms in the small sided game 1

V. H.

HR_{max} in LI: 183 BPM HR_{min} in RI: 115 BPM HR_{avg} in SSG: 156 BPM

Goalkeeper V. H.'s heart rate interval in this small sided game ranged from 115 up to 183 BPM, the average heart rate was 156 BPM.

From the perspective of training load zones, V. H. found himself most often within the aerobic-anaerobic zone – 5 min. and 14 s. out of the total time, which represents 32,7 %. Next was the anaerobic-aerobic zone – 3 min. and 4 s. (19,2 %) and the aerobic zone – 2 min. and 42 s. (16,9 %).

J. J.

HR_{max} in LI: 196 BPM HR_{min} in RI: 93 BPM HR_{avg} in SSG: 155 BPM

Goalkeeper J. J.'s heart rate interval in this small sided game ranged from 93 up to 196 BPM, the average heart rate was 155 BPM.

From the perspective of training load zones, J. J. found himself most often within the anaerobic-aerobic zone – 5 min. and 39 s. out of the total time, which represents 35,3 %. Next was the aerobic-anaerobic zone – 2 min. and 34 s. (16,1 %) and the aerobic zone – 1 min. and 37 s. (10,1 %).

M. Z.

HR_{max} in LI: 183 BPM HR_{min} in RI: 112 BPM HR_{avg} in SSG: 158 BPM

Goalkeeper M. Z.'s heart rate interval in this small sided game ranged from 112 up to 183 BPM, the average heart rate was 158 BPM.

From the perspective of training load zones, M. Z. found himself most often within the aerobic-anaerobic zone – 7 min. and 31 s. out of the total time, which represents 46,9 %. Next was the aerobic zone – 3 min. and 43 s. (23,2 %) and the anaerobic-aerobic zone – 1 min. and 7 s. (6,9 %).

A. P.

HR_{max} in LI: 200 BPM HR_{min} in RI: 125 BPM HR_{avg} in SSG: 167 BPM

Goalkeeper A. P.‘s heart rate interval in this small sided game ranged from 125 up to 200 BPM, the average heart rate was 167 BPM.

From the perspective of training load zones, A. P. found himself most often within the anaerobic-aerobic zone – 6 min. and 28 s. out of the total time, which represents 40,4 %. Next was the aerobic zone – 4 min. and 8 s. (25,8 %) and the aerobic-anaerobic zone – 3 min. and 21s. (20,9 %).

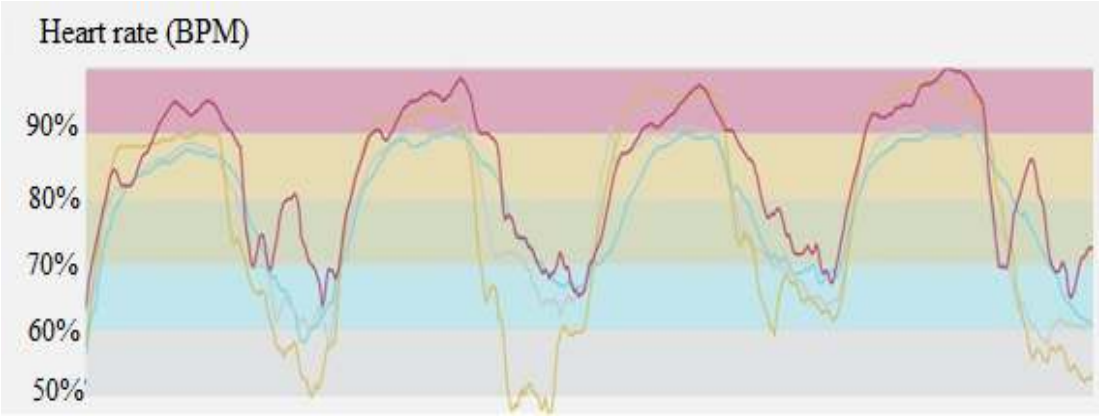

Fig. 3. Goalkeeper´s physiological curves in the SSG 1

Functional responses of goalkeeper´s organisms in the small sided game 2

V. H.

HR_{max} in LI: 171 BPM HR_{min} in RI: 111 BPM HR_{avg} in SSG: 146 BPM

Goalkeeper V. H.‘s heart rate interval in this small sided game ranged from 111 up to 171 BPM., the average heart rate was 146 BPM.

From the perspective of training load zones, V. H. found himself most often within the aerobic zone – 7 min. and 21 s. out of the total time, which represents 45,9 %. Next was the aerobic-anaerobic zone – 3 min. and 28 s. (21,6 %). He did not enter the anaerobic-aerobic zone at all.

J. J.

HR_{max} in LI: 188 BPM HR_{min} in RI: 116 BPM HR_{avg} in SSG: 155 BPM

Goalkeeper J. J.‘s heart rate interval in this small sided game ranged from 116 up to 188 BPM, the average heart rate was 155 BPM.

From the perspective of training load zones, J. J. found himself most often within the aerobic-anaerobic zone – 6 min. and 12 s. out of the total time, which represents 38,7 %. Next was the aerobic zone – 4 min. and 5 s. (21,6 %). J. J. spent only 1 min. and 36 s. (9.9 %) within the anaerobic-aerobic zone.

M. Z.

HR_{max} in LI: 172 BPM HR_{min} in RI: 115 BPM HR_{avg} in SSG: 146 BPM

Goalkeeper M. Z.‘s heart rate interval in this small sided game ranged from 115 up to 172 BPM, the average heart rate was 146 BPM.

From the perspective of training load zones, M. Z. found himself most often within the aerobic zone – 4 min. and 55 s. out of the total time, which represents 30,7 %. Next was the aerobic-anaerobic zone – 4 min. and 34 s. (28,5 %). M. Z. did not enter the anaerobic-aerobic zone at all.

A. P.

HR_{max} in LI: 193 BPM HR_{min} in RI: 92 BPM HR_{avg} in SSG: 151 BPM

Goalkeeper A. P.‘s heart rate interval in this small sided game ranged from 92 up to 195 BPM, the average heart rate was 151 BPM.

From the perspective of training load zones, A. P. found himself most often within the aerobic zone – 5 min. and 24 s. out of the total time, which represents 33 %. Next was the aerobic-anaerobic zone – 4 min. and 20 s. (27,1 %). A. P. spent only 1 min. and 27 s. (9,1 %) within the anaerobic-aerobic zone.

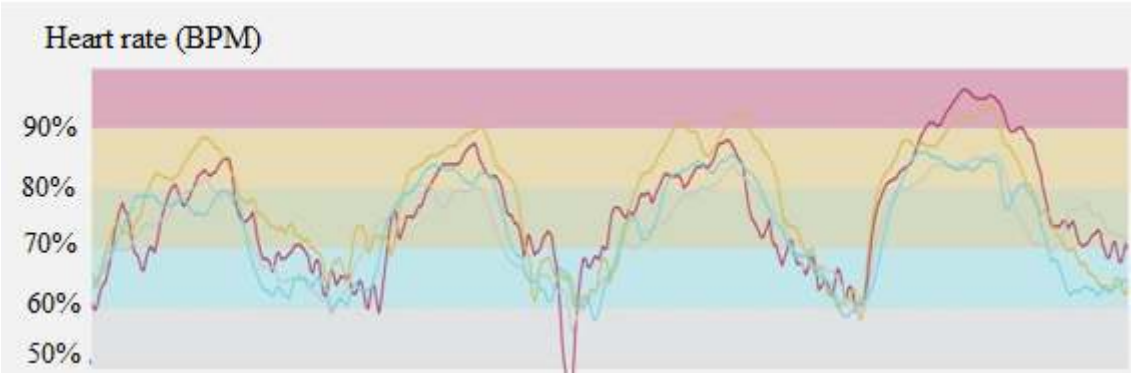

Fig. 4. Goalkeeper´s physiological curves in the SSG 2

Comparison of the operational responses of the goalkeeper´s organisms in the small sided games

The measured heart rate values, the time and percentage of goalkeepers load in the individual training zones were compared in both selected small sided games.

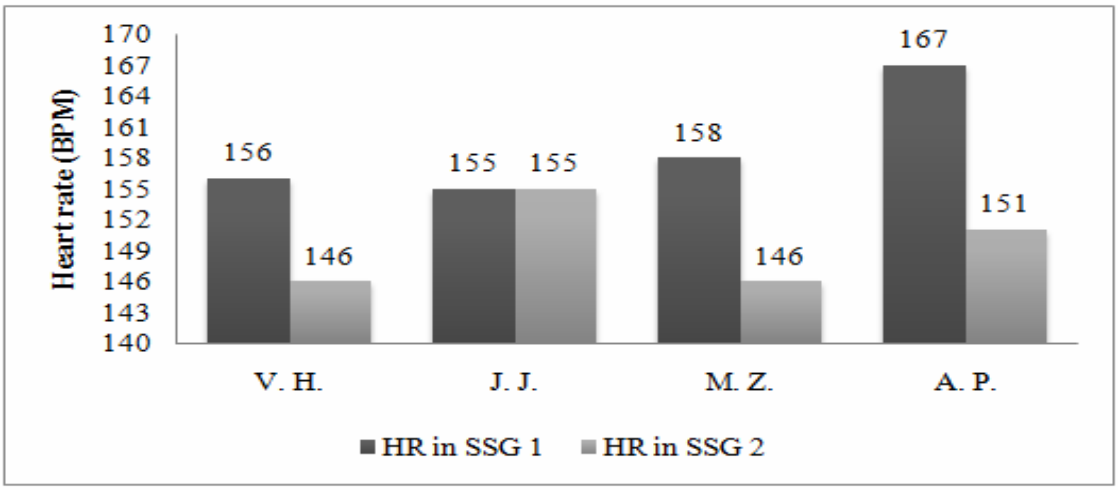

Fig. 5. The comparison of the average HR values of the players in SSG 1 and SSG 2

The highest average heart rate in SSG 1, 167 BPM, was achieved by the goalkeeper A. P. and the lowest HR, 155 BPM, was achieved by the goalkeeper J. J.

The highest average heart rate in SSG 2, 155 BPM, was achieved by the goalkeeper J. J. and the lowest HR, 146 BPM, was achieved by the goalkeepers V. H. and M. Z. The goalkeeper J. J. reached the lowest average heart rate in SSG 1 and the highest in SSG 2.

Three goalkeepers (V. H., M. Z. and A. P.) reached higher average HR values in SSG 1, whereas the goalkeeper J. J. achieved the same average HR value in both small sided games. Interestingly, in SSG 1 it was the lowest average HR value, while in SSG 2 it was the highest average HR value among all goalkeepers. The highest change in the average HR value can be observed with the goalkeeper A. P., where the difference between the two small sided games equals 16 BPM.

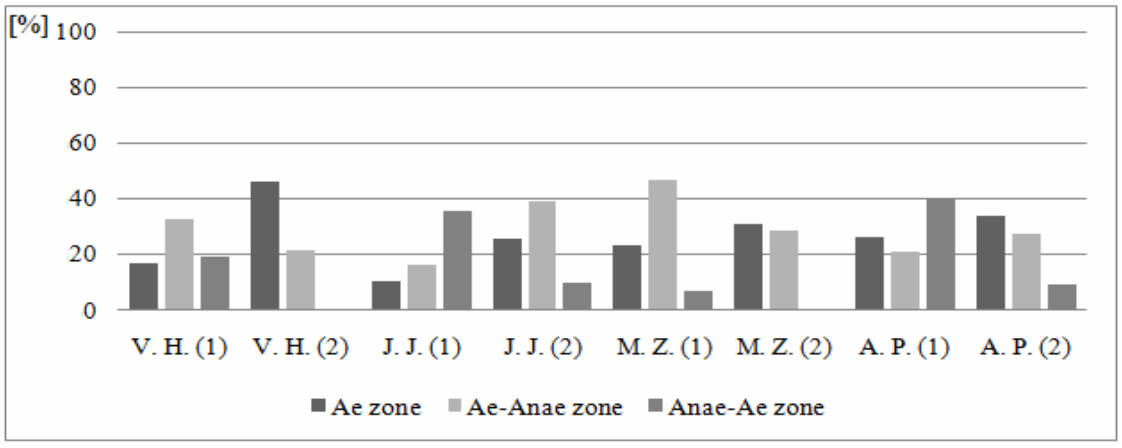

Fig. 6. Percentage of training load zones in SSG 1 and SSG 2

In the small sided game 1, the goalkeeper A. P. spent the most time in the aerobic zone – 25,8 % of his total time. The least time in this zone was spent by the goalkeeper J. J., 10,1 % to be exact. The most time in the aerobic-anaerobic zone was spent by M. Z. (46,9 %), and the most time in the anaerobic-aerobic zone was spent by the goalkeeper A. P. – up to 40,4 %, whereas the goalkeeper M. Z. only spent 6,9 % of his time here.

In the small sided game 2, the goalkeeper V. H. spent the most time in the aerobic zone – 45,9 % of his total time. The least time in this zone was spent by the goalkeeper J. J., 25,5 % to be exact. All four goalkeepers spent a similar amount of time in the aerobic-anaerobic zone, however the goalkeeper J. J. spent the most time here, exactly 38,7 %. Only two goalkeepers entered the anaerobic-aerobic zone for any length of time at all - J. J. (9,9 %) and A. P. (9,1 %).

From the perspective of the training load zones, we recorded changes with all goalkeepers. The goalkeeper V. H., who in SSG 1 moved mostly in the aerobic-anaerobic zone (32,7 %), was mostly in the aerobic zone (45,9 %) during SSG 2. The goalkeeper J. J., who in SSG 1 was mostly in the anaerobic-aerobic zone (35,3 %), spent most of his time during SSG 2 in the aerobic-anaerobic zone (38,7 %). Goalkeeper M. Z., who in SSG 1 was mostly in the aerobic-anaerobic zone (46,9 %), spent most of his time during SSG 2 in the

aerobic zone (30,7 %). The goalkeeper A. P., who in SSG 1 was mostly in the anaerobic-aerobic zone (40,4 %), spent most of his time during SSG 2 in the aerobic zone (33,7 %).

Discussion

The aim of the research was to find out, compare and expand the knowledge of the functional responses of the goalkeeper´s organisms to our small sided games in the phase of game activity improvement. We also tried to find out whether these responses of the body would be adequate and whether we would achieve a load that would develop the proficiency potential of the goalkeeper.

We assumed different heart rate values for goalkeepers due to varying load variability in individual small sided games. We failed to confirm this assumption statistically using the Wilcoxon T-test due to a small number of people in our set. On the basis of it, however, we calculated the Cohen r (effect size), where our result was r = 0.64, in other words a high effect, and thus we confirmed the assumption at least logically.

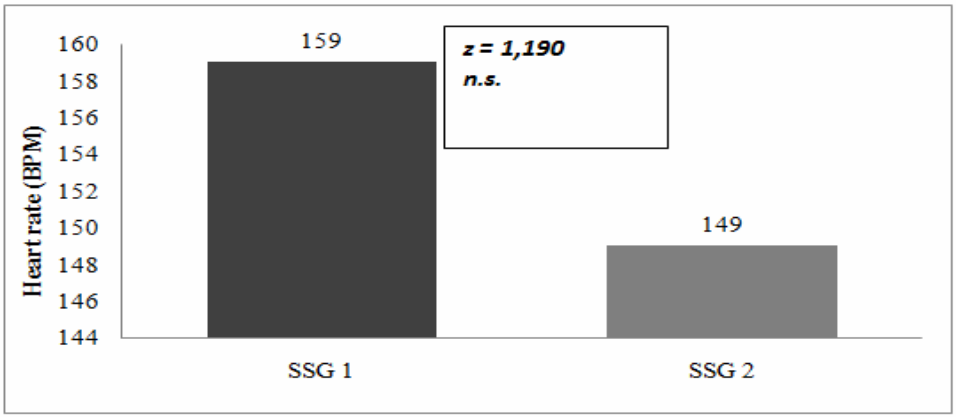

Fig. 7. Average HR values in the SSG

To determine the statistical significance, we also used a test of significance of two relative values. During SSG 1, the goalkeeper´s heart rate values averaged 159±5,5 BPM, and during SSG 2 the values averaged 149±4,4 BPM (z = 1.190). Therefore, the hypothesis has not been statistically confirmed by this test either.

Goalkeepers have achieved different mean heart rate values in individual games, and have also moved in different zones of training load. We can assert that the higher average values of HR were achieved in SSG 1. The goalkeepers J. J. and A. P. were in the anaerobic-aerobic zone in all four LI (SSG 1), and on the other hand, in SSG 2 they got into this zone in the third, resp. fourth LI for 1 min. and 36 s. (J. J.), resp. 1 min. and 27 s. (A. P.). The goalkeepers V. H. and M. Z., in addition to the first LI, reached the level of anaerobic threshold and the anaerobic-aerobic zone (SSG 1), whereas in SSG 2 they largely moved in the aerobic-anaerobic zone or in the aerobic zone. We can say that both the small sided games have brought about adequate adaptation changes and the development of the proficiency potential SSG 1 had a larger impact on the development of the proficiency potential of the goalkeepers. We recorded higher maximum and average values of the HR, as well as higher percentage and time representation in individual zones, which meant inducing the required adaptation changes in the goalkeeper´s organisms. The load intervals and rest intervals chosen by us were chosen correctly, that heart rate values for players during the rest intervals decreased to 120 to 130 BPM, resp. 130 to 140 BPM.

In rest intervals, the heart rate does not return to the baseline. From the point of view of adaptation processes, this interval of rest is understood as an extended stimulus for the cardiovascular and respiratory system (Sedláček et al. 2007). We used an interval method that is suitable for developing the proficiency potential. The same intervals were used by Babic in his work (2016), who chose load intervals and rest intervals of 2 minutes, and had the same effect of the heart rate dropping to 120 to 130 BPM, resp. to 130 to 140 BPM during the rest intervals. Holienka (2004) found, that the internal load of the players in SSG, that during rest intervals, the heart rate dropped to 120-125 BPM, creating the right conditions for further training sessions.

Based on this information, we agree with Hrnčiarik (2012) that at this stage of the youth sports preparatory in soccer, it is necessary to devote to the development of physical abilities and game skills when creating the conditions for regular individual training. Goalkeepers should improve the technical aspects of defensive and offensive play activities in the youth categories; they should focus on improving conditions under time and space pressure (match conditions) and under fatigue. Goalkeepers should gradually learn how to resolve complex game situations even when fatigued (Dobrý and Semiginovský 1988).

Conclusions

Keeping track of the functional responses of the soccer goalkeeper organisms in the improving phase can greatly assist the coaches in further planning, optimization and tracking of the training process. The reason why we made an effort to expand our knowledge on this issue is because modern technology has not seen much use in our domestic soccer, as opposed to soccer in the world. Many clubs in Slovakia do not have the financial resources to ensure the conditions for the progressive and maximum possible soccer advancement of the goalkeepers (or players in general) when it comes to the youth.

From our results, we can see that both small sided games have achieved their effect in terms of the development of the proficiency potential. SSG 1 had a more profound impact on adaptation changes in the body; the goalkeepers achieved higher average and maximum heart rates than during SSG 2.

Goalkeepers during cooperative specialist training can develop proficiency through specific training sessions. In a quality and properly managed specialized training process, the goalkeeper can advance and thus help his team in the match.

Based on results, we recommend for training practice:

-to carry out a specialized preparation of the goalkeepers training process based on developmental tendencies of goalkeeper,

-to monitor and evaluate the intensity of the internal load via the use of sporttesters throughout the training process,

-to set up the small sided games and the planning of the goalkeepers training process to adjust the external conditions to meet the requirements of the age category (organization, complexity, rules) and requirements of match.

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