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Original Article

Heart rate response differs between elite and non- elite Czech female basketball matches

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Abstract:
The aim of this study was to analyze heart rate (HR) response to Czech female basketball matches played at a different competitive level. Additionally, the influence of a game position was evaluated. Heart rate (HR) was monitored in eight official matches in elite: first league (N=8, age= 22,7 ± 1,9 years) and national (non- elite: second league) (N=9, age= 24,1 ± 2,3 years) female players. The average HR in matches was 91.9 ± 5.3 % of HR_{max} at elite level and 88.8 % ± 4.2 % of HR_{max} at national level ($P < .001$; $d = 0.58$). This difference was more pronounced in forwards ($P < .001$, $d = 1.2$) than centers ($P < .001$, $d = 0.41$) and guards ($P < .001$, $d = 0.18$). In conclusion, these results allow improving game understanding and helping coaches to prescribe accurate practice sessions based on individual requirements.
Keywords: Basketball, heart rate, intensity of exercise load, sporttester

Introduction

Basketball is one of the most popular sports games in the world. Recently, the basketball played these days has been speeding up (Gantois et al., 2017), both in terms of the players' movements and as well as in terms of their solving of game situations, and this trend is likely to continue in the future. It begins to be referred to as a "*non-stop game*", or "*coast to coast basketball*", that is a sports game in which there are almost no delays and slowdowns needed, for example, for the players to reassume their positions. A successful trainer who trains and nurtures players for this "modern" basketball must respond to these changes. Monitoring and drawing the right conclusions is a necessity in this respect because it influences the concept of preparation in terms of measuring forces, but above all in terms of the long-term development of game performance.

The relation between the exercise load during the match and exercise load during the training is rightly considered one of the key problems of basketball (Vala & Litschmannová, 2012). The presented work focuses on the comparison of inner load that can be understood as a response of the organism to physical activity; such load can be expressed by several characteristics. The heart rate level (SF) is one of the readily available physiological indicators, but it is also considered to be a reliable measure to assess the intensity of the exercise load (Achten & Jeukendrup, 2003; Benson & Connolly, 2011). Monitoring SF of sports game players during the training process as well as during matches is an integral part these days, while research focusing on the exercise load of sports game players has been carried out for over 15 years, e.g. Coutts, Reaburn & Abt (2003); Abdelkrim, El Fazaa, & El Ati (2007); Vaquera et al., (2008); Mathew & Delextrat (2009); Durocher, Guisfredi, Leetun, & Carter (2010); Montgomery, Pyne & Minahan, (2010); Cameron, Cameron, Dithurbide, & Lalonde (2012); Vala, Valová, Litschmannová, & Vančo (2013), Sannicandro, Cofano, & Rosa (2016); Conte et al., (2016); Dalen et al., (2016); Schelling & Torres (2016); Cuberek et al., (2017); Puente, Abián-Vicén, Areces, Lopez, & Coso (2017); Babic, Holienka, & Mikulic, (2018); Holienka (2016) etc. One of the reasons includes the continuously increasing demands on the condition of players and the meaning of condition indicators in the player assessment also continues to grow (Süss and Kaplan, 2011; Scanlan et al., 2018). Thus, we can expect further research in this area, as well as in other areas, such as external load analysis or detailed statistics (Ardigo et al., 2018; Clemente, Martins, Kalamaras, & Mendes, 2015; De Oliveira Junior et al., 2018) of the individual players during a match (Hunter et al., 2015; Ingebrigtsen et al., 2015; Šimonek, Horička, & Hianik, 2017; Sánchez-Sánchez, et al., 2018). This is why further research in this area can be expected in the future.

We consider the analysis of the individual players' exercise load during a champion match (or a friendly match) very important for the subsequent creation of a training plan, control and management of the training and the selection of suitable gaming exercises in the training (Benson & Connolly, 2011; Halouani et al., 2014;

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Randers et al., 2014). However, the load intensity of players during matches is influenced by many factors, and differences in the load intensity in relation to the player positions, gender and competition level were found. The long-term SF monitoring of female players in a selected team provided same-set data from two consecutive seasons when 80% of the team remained the same. Any potential differences in the load intensity of players during a match can be assigned to the different level of the opponents, different playing system of the opponents, and also better training on their side.

Aim

The aim of this paper was to compare the intensity of exercise load of first league and second league female basketball players during championship matches depending on player positions.

Material & methods

Study sample

The study sample for SF monitoring were the most active players of the second league women's basketball team (the second highest league), who played in the women's top league, i.e. the first league in the following season. The average age of monitored players in the first league was 22.7 ± 1.9 years, with an average height of 176.6 ± 7.9 cm and the average body weight of 68.9 ± 6.4 kg. After the team's promotion to the top league, team changes occurred and the average age of the team increased to 24.1 ± 2.3 years, while the average height was 179.1 ± 8.4 cm with the average body weight of 71.7 ± 10.5 kg. The changes in the increase of average height and weight were mostly caused by the addition to the player position of 1 forward and 2 centers, otherwise the team remained the same, only older by a year.

Methods

Maximum heart rate of the players was determined at the beginning of the season in the stress tests under laboratory conditions. The heart rate of players during the test was constantly monitored using the Polar sport tester. To determine the heart rate level of players during the match, the Polar Team^2 system² (Polar Electro, Oy, Finland) was used. In total, 8 championship matches in both of the leagues were analyzed, with the most active players who spent at least 25 minutes in the field being monitored.

Statistical data processing

The Polar Precision Performance^{TM} software was used to evaluate the data acquired from the measurements. The calculation of the average values of the players' HR used only the values of the individual time periods when the players actively participated in the game and the "live time" timer was running (Abdelkrim, El Fazaa, & El Ati, 2007, Vala & Litschmannová, 2012). The statistical program IBM SPSS Statistics 22.0 was used to statistically process the obtained data. Statistical decision making was performed at 0.05 significance level. Normality of the data as a prerequisite for the use of parametric test forms was rejected in most cases (Shapiro–Wilk test, p-value <0.05) and therefore nonparametric forms of testing (Kruskal–Wallis test and Mann–Whitney test) were used to assess the statistical significance of the observed differences. The obtained results were also evaluated from the point of view of size of effect by Cohen (1988) and Hendl (2009), both of whom recommend the "*Cohen's d*" values for size of effect (0.2 = small effect, 0.5 = medium effect, 0.8 = great effect).

Results & discussion

One of the most significant factors affecting the intensity of exercise load of sports game players is the player's position, with the observed differences being assessed as statistically significant (Abdelkrim, El Fazaa, & El Ati, 2007; Mathew & Delextrat, 2009; Vala & Litschmannová, 2012; Vala & Petr, 2013, Abbott, Brickley, & Smeeton, 2018).

Table 1: Basic descriptive statistics of the intensity of the exercise load of first league and second league female players, depending on their positions in the game (expressed by HR values)

Position	League	Mean (95 % CI)	SD	HR_{Max}
Guards	First	174.8 (174.5; 175.1)	9.2	194
	Second	183.3 (182.7; 184.0)	6.7	202
Forwards	First	182.9 (182.6; 183.2)	12.3	206
	Second	169.7 (169.2; 170.2)	6.7	188
Centers	First	190.6 (190.3; 190.9)	11.3	212
	Second	174.4 (173.8; 175.0)	9.1	195
Total	First	183.2 (183.0; 183.4)	12.8	212
	Second	176.1 (175.7; 176.5)	10.3	202

Note: 95% CI- 95% Confidence Interval for Mean (Lower Bound; Upper Bound). SD- Standard Deviation, HR_{max}- maximal heart rate during a championship matches

When comparing the exercise load intensity of the monitored players expressed by their HR values, the highest intensity was reported in first league players at the center position (190.6 ± 11.3), then in second league guards (183.3 ± 9.7) and the lowest HR values were found in second league players at the forward position (169.7 ± 6.7). One first league player at the center position also had the highest HR value, namely 212 heartbeats per minute, as shown in Table 1.

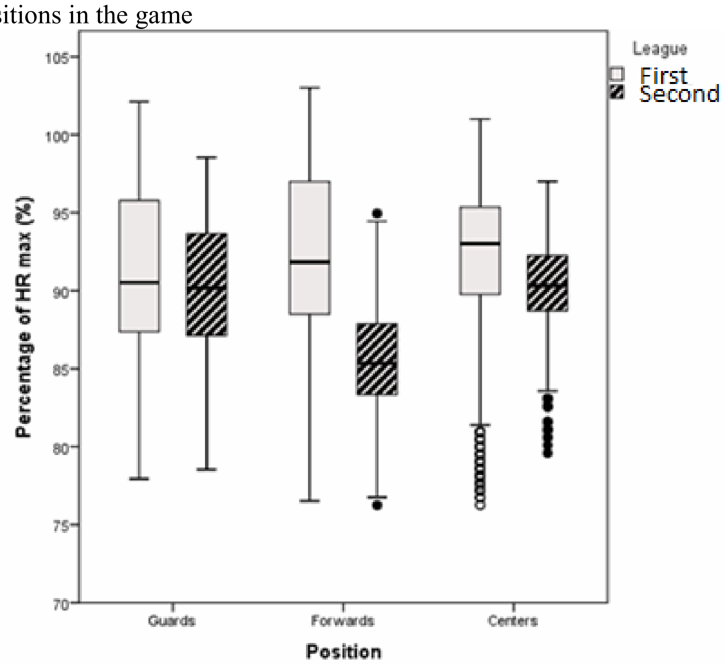
When comparing the exercise load intensity by HR values only, it is clear that there are differences in statistical significance and size of effect of individual player positions (Table 1). Here, however, it is necessary to take into account different maximum HR values of individual players, which were determined before the start of the season in the laboratory conditions. Table 2 shows the analyzed exercise load intensity expressed as a percentage of the individual players' maximum HR.

Table 2: Intensity of the exercise load of the first league and second league female basketball players, depending on their positions in the game (expressed by the percentage of HR_{max})

Position	**League**	**Mean (95 % CI)**	**SD**	**Percentage of HR_{Max} (%)**	**p-value**	**ES**
Guards	First	91.1 (90.9; 91.2)	5.6	102.1	< 0,001	0,18
	Second	90.1 (89.8; 90.4)	4.4	98.8		
Forwards	First	92.3 (92.2; 92.4)	5.6	103.0	< 0,001	**1,2**
	Second	85.7 (85.5;85.9)	3.4	95.0		
Centers	First	92.2 (92.1; 92.3)	4.8	101.0	< 0,001	0,41
	Second	90.3 (90.1; 90.5)	2.9	98.8		
Total	First	91.9 (91.8; 92.0)	5.3	103.0	< 0,001	0,58
	Second	88.8 (88.7; 89.0)	4.2	98.8		

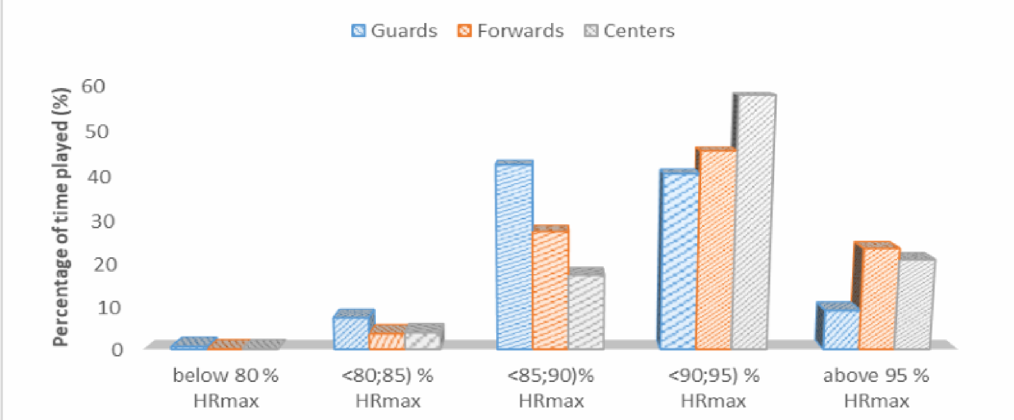
Note: 95% CI- 95% Confidence Interval for Mean (Lower Bound; Upper Bound). SD- Standard Deviation, HR_{max}- maximal heart rate during a championship matches, p-value (Mann-Whitney test), ES- Effect Size (Cohen´s *d*)

Picture 1: A box plot comparing the percentages of first league and second league female players, depending on their positions in the game



The highest exercise load intensity values of 92.3 ±, 5.6% of HR_{max} were found in first league players at the forward position, while paradoxically the lowest values were also found in forward players, but in the second league (85.7 ± 3.4% of HR_{max}). These differences can, of course, be considered statistically significant (p-value < 10^{-3}), and as for size of effect, it can also be considered big (Cohen's d = 1.2). These differences can be caused mainly by the change of the gaming system after the promotion to the highest competition. While in the second league (i.e. the second highest competition) the game was based mainly on "picks and rolls", i.e. the offensive combination of the guard and the center, following the promotion to the highest competition, it was necessary to complement the team with high-quality players in the forward position and play more complexly using multiple offensive game combinations of systems. The first league forward players also showed the highest average exercise load intensity values, namely 92.3 ± 4.8% of HR_{max}, as can be seen from Chart 1 or Table 2. Also, when comparing the intensity of exercise load of the player at the remaining positions (guards and center), the observed differences can be considered statistically significant, but in terms of size of effect, however, we cannot talk about a big effect in case of the guards (Cohen's d = 0.18) and also regarding the center players it can be stated that there are only minor differences (Cohen's d = 0.41; Cohen, 1988). From Table 2 and Picture 1, we can also discern that in the highest competition there are also values exceeding the maximum HR of individual players that were determined in the laboratory conditions. Here, it would seem more appropriate to determine the HR_{max} values by using field tests such as the "Yo-Yo Intermittent Recovery Test Level 1" (Bangsbo, Iaia & Krustrup, 2008) that more closely "simulate" the typical exercise load of sports game players for whom intermittent exercise load is typical.

Picture 2: Chart of the exercise load intensity distribution by individual zones expressed as a percentage HR_{max} (%)



	below 80 % HRmax	<80;85) % HRmax	<85;90)% HRmax	<90;95) % HRmax	above 95 % HRmax
Guards	0,64	7,40	42,41	40,42	9,13
Forwards	0,00	3,67	27,34	45,5	23,49
Centers	0,00	3,90	17,36	57,82	20,93

Based on the nonparametric Kruskal–Walliss test, the players of both leagues were found to have statistically significant differences (p-value $<10^{-3}$) between the intensity of exercise load during the match, i.e. during the first, second, third and fourth quarter at 0.05 significance level. In both cases, the first quarters of the matches were played with a higher exercise load intensity compared to the remaining three quarters. Our results thus confirmed the general assumptions and conclusions from previous studies (e.g. Mathew & Delextrat, 2009), when a decrease in the intensity of exercise load during a match was expected (published). In the case of the first league, a decrease in the intensity of the load in the course of the match was indicated by a 2% decrease in HR_{max}, while in the case of the second league matches, it was a decrease of 2.3% in HR_{max}. When assessing the effect size of this difference, however, we must again note that this is a minor difference (Cohen's d = 0.43).

As can be seen on the chart (Picture 2), the first league players at the center positions were at the HR_{max} level above 90% during 78% of the elapsed time, while in case of the guards it was only about 49% of the elapsed time. Our average values of the players' exercise load intensity during the matches are comparable with the results obtained from the first league basketball players of the cadets category (Vala & Litschmannová, 2012), which were published as the average HR of the most active players during a championship match: 176.1 ± 5.8 beats per minute, which corresponded to 90.6 ± 2.9 % of HR_{max}. The mentioned paper also presented statistically significant differences in the players' exercise load intensity depending on their positions, with the lowest values found in the players at the center positions: the average value was 88.8% of HR_{max}. On the contrary, lower basketball players' exercise load intensity values were measured in real games by Puente (2016), specifically 89.8 ± 4.4% of HR_{max}.

In general, differences in the exercise load intensity of basketball players depending on their positions are caused by their different locations in the game and, consequently, their different roles on the court, where e.g. the task of center players is "screening" players with and without the ball. Unlike guards, who are constantly in motion – both in defense and in attack –, center players perform more game activities of a "static" individual. Related to the in-game use of players at different positions is also the game's systems of defense (zone or man-to-man defense systems) and offense (e.g. different types of press defense). Another important factor affecting the resulting values of HR is also the experience of the players gained during their career, which brings changes to the structure of the player's performance throughout the game. In addition to the player's position, the exercise load intensity can also be affected by the result of the match, where the score is tied and players of both teams are forced to play throughout the match with maximum effort, against the best players of the opponent. On the contrary, in cases where the outcome is already decided during the match, a more frequent rotation of the top players occurs on both sides, so the opportunity is also given to reserve players. The decrease in the exercise load intensity during the match we observed could be caused by several factors. The bodies of the players in the first quarter were probably not burdened with an oxygen debt as opposed to the remaining three quarters. During the third and fourth quarters, the players could experience degradation of lactate ion, due to sweating the amount of water in the body could also drop (reducing the amount of blood plasma), which according to Benson and Connolly (2012) can be compensated by an increased heart rate. Monitoring of exercise load intensity in sports games characterized by the interval load is problematic. However, unlike the more specific indicators such as oxygen consumption (VO_2), monitoring of HR is a practical and widely usable method (Achten & Jeukendrup, 2003; Buchheit, 2014; Bosquet, Merkari, Arvisais, & Aubert, 2008). For further specification of the players' exercise load in a basketball match, the research will need to be expanded to heart rate monitoring for larger sample of players (teams) and also monitoring of load in multiple games maintaining the same conditions. By contrast, it would be appropriate to expand the research by monitoring other parameters, such as the relationship between the exercise load intensity and the amount of minutes played or analysis of the players' HR throughout the match, i.e. including the periods when the timer is off, or the relationship between the exercise load intensity and a player's validity during their presence on the court.

Conclusion

The game load analysis of the players during the monitored matches in both leagues pointed out the basic parameters that the trainers should use when preparing the training. The aim of the study was to analyze the progress of the exercise load intensity of female basketball players during matches of the same team in two different competitions depending on their positions in the game (guard - forward – center). While the average calculated HR_{max} value for first league players on all positions in the match was 91.9% ± 5.3%, for players of the second league women's basketball the average exercise load intensity was established at the level of 88.8 ± 4.2% of HR_{max} during a stress test. However, as in the sports practice we generally do not encounter situations with random samples, the results were also assessed from the perspective of the so-called effect size, with the difference qualifying as one of medium significance (d = 0.58). The obtained results of the load of players during championship matches showed significantly higher values of load intensity in the first league and they should be now used for the preparation of the training plan and for the selection of appropriate methodological-organizational forms of training in the same age, but above all performance category.

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