

DIFFERENCES IN PHYSIOLOGICAL LOAD OF THE REFEREES WITH CONSIDERATION TO THE PERIOD OF THE BASKETBALL GAME

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SUMMARY

The main object of this research was to determine the existence of statistically significant differences in physiological load of the referees considering the period of the basketball game. The sample of subjects consisted of 31 referees, average age of 33.35 ± 5.17 , from the A referee list of the 1st Croatian Basketball League in the contest season 2008/2009. The sample of variables consisted of the following: *FSM* - average heart rate; *F_{max}* - maximum heart rate; *E* - energy consumption (kcal/min). Measuring was done during official games of the 1st Croatian Basketball League in the contest season of 2008/2009. During the game, heart rate was measured with a cardiometer (an electronic device for heart rate measurement), produced by *POLAR*, model *RS400* (Finland). Data processing was done using a programme package *STATISTICA* for Windows, ver 8. Based on the obtained results of univariate variance analysis it was concluded that there are no statistically significant differences in the physiological load between the first and second half - time, as well as between particular quarters of basketball games.

Key Words: physical - motor preparation, heart rate, energy consumption.

INTRODUCTION

In now days basketball is characterized by high level of activity in all 40 minutes of its duration, which demands a great physical - motor preparation of the players (Matkovic, Matkovic, & Knjaz, 2005). The past researches of physiological load of the players during a game have pointed out to its high level of intensity (Beam & Merrill, 1994; Hoffman, 2003). The average heart rate of the players during a game is at 87% of the maximum heart rate (Mcdougal, Wegner, & Green, 1991), or in other words, 75% of the total game time the players heart rate amounts above 85%, and 15% of the time amounts above 95% of the maximum heart rate (McInnes, Carlson, Jones, & McKenna, 1995).

Both the players and the basketball referees make a component part of every basketball game. The ultimate outcome of most basketball games is decided in the last minutes when the level of physical - motor preparation of the players, their psychological stability and changes in team tactics, greatly influence the final number of technical - tactical errors and errors

that result from disregarding the regulations of the game of basketball (Mildenhall & Holmin, 2004). To make the referees decision as better and more correct as possible, during the game the referee always has to be at the right place and have a quality point of view of the situation. The stated surely demands a great physical preparation of the referees, as well as good visual perception, mental ability, focus of attention, readiness and ability to make fast decisions. Regardless of great importance of the basketball referees, there are very few scientific researches which have dealt with them as their main topic. The past researches of the physiological load of the basketball referees have shown a great level of stress to their organism.

The referees are exposed to high level of load while officiating an entire game, especially in the final moments when their activity in the sense of making a larger number of rulings, increases. In other words it can be assumed that physiological load of the referees changes as the game is coming to an end. The main object of this paper was to determine the existence of statistically significant differences in physiological load of the referees considering a period of the basketball game.

METHODS

Sample of subjects

The sample of subjects consisted of 31 referees average age of 33.35 ± 5.17 , from A referee list of the 1st Croatian Basketball League, season 2008/2009. The average height of the referees was 186.34 ± 5.40 cm, and the average body mass was 88.04 ± 7.47 kg. Body mass index varied in the range of 21.80 to 29.80 kg/m² with the average value of 25.32 ± 1.60 kg/m². For the purpose of this research the level of maximum relative oxygen intake was determined using a standard protocol for estimating functional abilities, done in the Sports – diagnostic Centre of the Faculty of Kinesiology, University of Zagreb, which represents a progressive test of load on a moving carpet with standard inclination of 1,5% (spirometry method). The average value of maximum relative oxygen intake was 52.49 ± 5.80 ml/kg/min, with the range of results from 43.15 to 65.56 ml/kg/min. Values of the heart rate in rest have varied in the range of 42 to 86 beats/min with the average value of 66.22 beats/min.

The referee list was defined by the Croatian Basketball Referee Association, and it is made every year according to the results of officiating in the past regular season.

Sample of variables

The sample of variables consisted of the following: Fs - average heart rate; FSmax – maximum heart rate; E – energy consumption (kcal/min). The physiological load of the referees was followed by heart rate measuring during official basketball games of the 1st Croatian Basketball League in the season 2008/2009. The heart rate during a game was measured with a cardiometer (an electronic device for heart rate measuring), produced by POLAR, model RS400 (Finland). Before the beginning of the game, cardiometers were put on the referees in the way that an electronic watch (a signal receiver) was placed around the wrist, and a band with the signal transmitter was placed around the chest beneath the official shirt. The electronic devices for heart rate measuring (cardiometers) were set in motion just before the beginning of the game. The devices were recording the heart rate in an interval of 5 seconds. The game was monitored by official and professional person who noted all time intervals during the game using a stop – watch. Every game was also monitored using a video camera which will later allow more quality and more precise analysis of the obtained data. At the end of the game, data from the electronic measuring device were transferred to the computer which

enabled further data analysis using an adequate programme application (Polar Pro Trainer 5).

Methods of data processing

Data processing was done using a programme package STATISTICA for Windows, ver 8. The first step in data processing was to calculate central and dispersive parameters for all variables. For each variable the following parameters were calculated: mean (*M*), standard deviation (*SD*), minimum value (*MIN*), maximum value (*MAX*).

Statistical difference significance between particular parts of the game in variables for estimating the physiological load, were tested using univariate variance analysis (ANOVA).

RESULTS AND DISCUSSION

The obtained results from Table 1 show that in the first quarter the average heart rate amounted 141 ± 9.88 beats/min, which is in average $75.60 \pm 5.13\%$ of the maximum heart rate. The average value of heart rate moved in the range of 122 to 162 beats/min, while the highest measured value during first quarter was 187 beats/min. The average energy consumption during first quarter was 14.29 ± 2.24 kcal/min.

In the second quarter the average heart rate was 140.25 ± 9.62 beats/min, which is in average $75.19 \pm 4.78\%$ of the maximum heart rate. The average value of heart rate in second quarter moved in the range of 123 to 167 beats/min, while the highest measured value of the heart rate was 186 beats/min. The average energy consumption was 14.12 ± 1.99 kcal/min.

During the third quarter the average heart rate amounted 139.48 ± 10.49 beats/min, in the range of average values of 123 beats/min (the lowest value) to 167 beats/min (the highest value). The obtained average heart rate value matches the value of $74.77 \pm 5.17\%$ from the calculated maximum heart rate. The highest measured value of the heart rate in third quarter was 188 beats/min, while the average energy consumption was 13.94 ± 2.08 kcal/min.

During the fourth quarter the measured average heart rate value amounted 137.80 ± 9.77 beats/min, with the lowest average value of 121 beats/min and the highest value of 163 beats/min. The obtained average heart rate value in the last quarter matches the value of $73.88 \pm 4.91\%$ of the maximum heart rate. The highest noted heart rate value in the last quarter was 184 beats/min, while the average energy consumption amounted 13.65 ± 1.76 kcal/min.

TABLE 1

Basic statistic descriptive parameters of variables for estimating the physiological load of the referees while officiating basketball games

ID	MU	<i>M</i>	<i>SD</i>	<i>MIN</i>	<i>MAX</i>
HRM1	beats/min	141.00	9.88	122.00	162.00
%HRmax1	%	75.60	5.13	67.58	87.79
EMmin1	kcal	14.29	2.24	9.57	19.17
HRmin1	beats/min	108.87	12.03	79.00	133.00
HRmax1	beats/min	164.51	10.00	146.00	187.00
HRM2	beats/min	140.25	9.62	123.00	167.00
%HRmax2	%	75.19	4.78	67.34	85.46
EMmin2	kcal	14.12	1.99	10.22	17.36
HRmin2	beats/min	110.83	12.62	90.00	145.00
HRmax2	beats/min	163.67	8.65	147.00	186.00
HRM3	beats/min	139.48	10.49	123.00	167.00
%HRmax3	%	74.77	5.17	63.26	85.46
EMmin3	kcal	13.94	2.08	10.29	18.00
HRmin3	beats/min	106.32	11.87	83.00	123.00
HRmax3	beats/min	162.19	10.57	141.00	188.00
HRM4	beats/min	137.80	9.77	121.00	163.00
%HRmax4	%	73.88	4.91	61.73	83.72
EMmin4	kcal	13.65	1.76	10.43	17.45
HRmin4	beats/min	109.58	12.07	90.00	139.00
HRmax4	beats/min	161.67	9.25	142.00	184.00
HRM1P	beats/min	139.93	9.41	122.00	164.00
%HRmax1P	%	75.08	4.81	68.13	86.62
EMmin1P	kcal	14.03	2.03	9.78	17.93
HRM2P	beats/min	137.87	9.86	121.00	164.00
%HRmax2P	%	73.92	4.97	61.73	84.30
EMmin2P	kcal	13.66	1.87	10.34	17.61

Legend: **ID** - Indicator; **MU** - Measure unit; ***M*** - Sample mean; ***SD*** - Standard deviation; ***MIN*** - Minimum value; ***MAX*** - Maximum value; **HRM1,2,3,4** - Average heart rate 1,2,3,4 - quarters; **%HRmax1,2,3,4** - Total percentage of maximum heart rate 1,2,3,4 quarters; **EMmin1,2,3,4** - Average energy consumption per minute 1,2,3,4 quarters (Prosječna energetska potrošnja u minuti 1,2,3,4 četvrtina); **HRmin1,2,3,4** - Lowest heart rate value 1,2,3,4 - quarters; **HRmax1,2,3,4** - Maximum heart rate value 1,2,3,4 - quarters; **HRM1P** - Average heart rate in first half - time; **%HRmax1P** - Total percentage of maximum heart rate in first half - time; **EMmin1P** - Average energy consumption per minute in first half - time; **HRM2P** - Average heart rate in second half - time; **%HRmax2P** - Total percentage of maximum heart rate in second half - time; **EMmin2P** - Average energy consumption per minute in second half - time.

The average heart rate in first half - time (first and second quarter and break between them) amounted 139.93 ± 9.41 beats/min, which matches the value of $75.08 \pm 4.81\%$ of the maximum heart rate. The average maximum heart rate value during first half - time amounted 166.12 ± 9.73 beats/min, and the average energy consumption amounted 14.03 ± 2.03 kcal/min.

Similar results were obtained during second half - time (third and fourth quarter and break between them), where the average heart rate value amounted 137.87 ± 9.86 beats/min. The obtained average heart rate value matches the value of $73.92 \pm 4.97\%$ of the maximum heart rate. The average maximum heart rate value during second half - time amounted 164.16 ± 9.69 beats/min and the average energy consumption amounted 13.66 ± 1.87 kcal/min.

Statistical difference significance between particular parts of the game in variables for estimating the physiological load were tested using the univariate analysis of variance (ANOVA).

TABLE 2

Testing of differences between first and second half – times of basketball games in variables for estimating the level of physiological load of the referees while officiating – univariate variance analysis (ANOVA).

Variables	1 st half-time		2 nd half time		F	p
	M	SD	M	SD		
HRM	139.93	9.41	137.87	9.86	.710	.402
HRmax	166.12	9.73	164.16	9.69	.636	.428
E kcal/min	14.03	2.03	13.66	1.87	.561	.456

Legend: 1st half–time, first and second quarter and break between them; 2nd half–time, third and fourth quarter and break between them; **HRM** - Average heart rate; **HRmax** – Maximum heart rate; **E** – Energy consumption; **M** - Sample mean; **SD** - Standard deviation; **F** - F-ratio; **p** – Probability.

TABLE 3

Testing of differences between first and second half – times of basketball games in variables for estimating the level of physiological load of the referees while officiating – univariate variance analysis (ANOVA).

Variables	1 st quarter		2 nd quarter		3 rd quarter		4 th quarter		F	p
	M	SD	M	SD	M	SD	M	SD		
HRM	141.00	9.88	140.25	9.62	139.48	10.49	137.80	9.77	.586	.625
HRmax	164.51	10.00	163.67	8.65	162.19	10.57	161.67	9.25	.572	.634
E kcal/min	14.29	2.24	14.12	1.99	13.94	2.08	13.65	1.76	.569	.636

Legend: **HRmax** – Maximum heart rate; **E** – Energy consumption; **M** - Sample mean; **SD** - Standard deviation; **F** - F-ratio; **p** – Probability.

Based on the obtained data of univariate variance analysis (Table 2) it is concluded that there is no statistically significant shift between first (first and second quarter and break between them) and second half – time (third and fourth quarter and break between them) of the basketball game in the variables for estimating the level of physiological load: FS - average heart rate ($F = .710, p = .402$); Fsmax – maximum heart rate ($F = .636, p = .428$); E – energy consumption ($F = .561, p = .456$); with the level of significance of .05.

Therefore, in second half – time the values of energy consumption, average heart rate and maximum heart rate are somewhat lower, however the differences are not statistically significant at the level of significance of .05.

Although, the values of central parameters of average and maximum heart rate as well as the energy consumption, are gradually reduced as the game is coming to an end. From the obtained data of univariate variance analysis (Table 3) it can be seen that there are no statistically significant differences

between particular periods (quarters) in the level of physiological load of the referees during the game. In other words, the obtained statistic results show that variability between the groups is not significantly bigger than variability within the groups at the level of significance of .05.

Based on the obtained data of the relative maximum oxygen intake it can be concluded that the referees have a well developed aerobic capacity (Leicht, 2007), similar to professional basketball players (Castagna et al., 2009) and the referees from other team sports (Casajus & Castagna, 2007; Castagna & D'Ottavio, 2001; Krustup & Bangsbo, 2001).

The obtained data are pointing out to a high physiological load which doesn't statistically significant change at well prepared referees considering the period of the game.

In view of proven high physiological load which results from dynamics of the game of basketball, it can be assumed that physical – motor preparation of the referees is of high importance to their quality of officiating.

Research results fold over with results obtained in other researches of physiological load of the referees during basketball games. Thus, Leicht in his researches noted the values of heart rate during a game between 130 and 150 beats/min, or 73-79% of the maximum heart rate. More than 63% of the time interval the referees spent in an intensity load higher than 70% of the maximum heart rate. Based on these results it was concluded that the referees are exposed to high level activities during an entire game (Leicht, 2004, 2008). In the research of Rupčić (2010), based on the obtained heart rate values during officiating basketball games and heart rate values at anaerobic threshold, it was concluded that basketball referees spent 50% of an overall game time in the zones of high aerobic load. Taking into consideration only the quarters, without the breaks between them, that percentage amounts up to 60%. Considering the time spent in particular intensity zone, and also the energy consumption values, it was concluded that the referees, while officiating a game, are exposed to high physiological load (Ibid).

Similar results were also obtained in other team sports such as football and rugby (Barbero Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012; Catterall, Reilly, Atkinson, & Coldwells, 1993; D'Ottavio & Castagna, 2001; Martin, Tolfrey, Smith, & Jones, 2005). Although significant differences in average heart rate values between first and second half - time weren't determined, there are however certain variations. That's how D'Ottavio and Castagna (2001) noticed that cardiovascular system load of the Italian Serie A referees, was lower in first 15 minutes of the first half - time, while Helsen and Bultynck (2004) noticed significant variations of heart rate during important games. The lowest heart rates were measured in first 15 minutes of both half - times, and the highest in last 15 minutes also in both half - times. This increase at the end of half - times, authors link to an increased effort of the referees in keeping up with the game rate. There are many other factors which influence the change in heart rate besides the intensity of the game, such as dehydration, thermal stress, psychological stress, high intensity activities.

CONCLUSION

With consideration to determined high physiological load of the referees during an entire basketball game, it is logical to conclude that the referees must have optimally developed physical - motor preparation. Otherwise they wouldn't be able to follow dynamic movement of the players and accordingly

complexed game situations, which in the end would result in bad, not precise enough estimation of game situations. All of the stated would directly result to the outcome of the game itself. That observation comes out of the fact that bad physical - motor preparation influences on a faster show of weariness, which will ultimately result in considerable reduction of concentration in the given moment, which implies a very short time interval when it is necessary to form a judgement about a specific game situation. Of course, good physical - motor preparation of the referees is only one of the prerequisites for quality officiating. It can be assumed that experience in officiating, theoretical knowledge and feeling for the game are certainly additional factors which influence the quality of every referee.

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