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The relationship between physiological and mechanical load indicators and offensive team efficiency in junior male basketball

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ABSTRACT

The aim of this investigation was to identify the players physiological and mechanical load demands in association with the offensive teamwork structure and efficiency at the junior level of basketball performance. Sixteen elite male junior (age 17,4 ± 1,2 years; height 193,7 ± 7,4 cm; mass 84,4 ± 11,1 kg) Estonian basketball players volunteered to participate in this study. The data were gathered from 197 ball possessions in three competitive games played in division 1 of Estonian Championship. The heart rate and mechanical activity values of each player partakes in team ball possession were obtained by the physiological status monitoring device Zephyr™ BioHarness™. The technical/tactical indicators of the team offensive activity, „teamwork intensity“ and outcomes were notated to the Microsoft Office Excel table. The last stage of data processing provided the analysis of aggregated data by Data mining method. The sample of associative rules for the team scoring (depended variable) more than the average 0,90 (predicted value) highlights the role of the point guardś high level of heart rate (181 BMP on average) for increasing the offensive efficiency. Furthermore, the efficient possessions are characterized by the high values of mechanical activity (>1) and heart rate (165-191 BMP) of forwards accompanied by a high teamwork „intensity“ indicator (0,83-. 1,55). Based on these results, we can conclude that the players higher mechanical activity and heart rate values ensure a higher offensive efficiency of a basketball team. **Key words**: BASKETBALL, FUNCTIONAL LOAD, OFFENSIVE TEAMWORK ACTIVITY, EFFICIENCY.

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INTRODUCTION

The game efficiency in basketball may depend on the technical, tactical, psychological, physical preparation amongst others. The competitive activity in basketball can be understood as the holistic system of interrelated technical-tactical components dedicated to achieve a specific goal. Such system is brought to the existence by the cooperation of the teammates in the changing situations of the game (Bazanov, B. 2007). In order to achieve high game efficiency, especially in offensive phase, players need to be well prepared diversely. In addition to the technical and tactical skills and abilities basketball players need a high level of aerobic endurance, speed and explosive power (Boone & Bourgois, 2013). Contemporary accelerometers and heart rate monitoring systems are useful for differentiating the practice and competition demands of basketball (Montgomery et al, 2010). There are a number of studies which identified the physiological intensity of load in the competitive game environment. McInnes et al. (1995) explained that the heart rate (HR) of Australian elite basketball players was equal to 169 ± 9 BPM in the mean which accounted for 89 ± 2% of maximal heart rate (HRmax). In a study conducted by Hůlka et al. (2013) were analyzed thirty-two Czech top male junior basketball players. Results showed that the average heart rate was measured to be 167.47 ± 13.01 beats · min. –1, which corresponded to 85.06 ± 6.40% of peak heart rate. The percentages of the total time spent, over and under 85% were 63.12% and 36.88%, respectively. Major findings of the study conducted by Köklü et al (2011) showed, that court positions have different demands and physical attributes and they are specific to each playing position in professional basketball players. The physical demands of modern basketball were assessed by investigating 38 elite under-19-year-old basketball players in the study performed by Abdelkrim et al. (2007). The authors identified that the mean (SD) heart rate during total time was 171 (4) beats/min, with a significant difference (p 0.01) between guards and centres. Among Greek elite young basketball players the average heart rate at the anaerobic threshold was 163 beats/min and this value corresponded to 86 % of maximum heart rate (Apostolidis et al., 2004).

A series of studies carried out in the conditions of a training session or training game have shown lower level of physical and physiological characteristics in comparison with a competitive game (Montgomery et al., 2010; Rodríguez-Alonso et al. (2003). The evaluation of the physiological responses of male basketball players during usual basketball ball-drills showed increments in physiological demands when reducing the number of players over the same playing court (Castagna et al 2011).

On the basis of the results given above, we can say that the authors have thoroughly investigated the functional demands of basketball players, but without linking them to a technical/tactical components and outcomes of the game.

On the other hand a number of studies have examined the different technical/tactical aspects of the game. Some authors have turned their attention to the efficiency indicators in the game of basketball. Factors that contribute to the success or improve performance in invasive games are passing, field position, shots, time in possession, goals and others (Hughes and Bartlett R. 2002). Tavares and Gomes (2003) analyzed the set offense and fast break situations and recorded their frequency, duration and outcome actions in high performance level junior male basketball. The results showed, that the main game method was set offense out of which 3/4 have duration between 13 and 18 seconds. The duration of the major amount of fast breaks is between 4 and 6 seconds. Based on the analysis of the US national basketball teamś offensive activity played on 2014 FIBA World Cup games Bazanov and Rannama (2016) found that the total time duration of the successful fast break was equal to 3,84 seconds, accompanied by a minimum number of elements (≤3) in the offensive zone which ends with lay-up or dunk. Cardenas et al (2015) notes in their study, that over nine out of ten fast breaks consist of the maximum of two passes. Mendes and Janeira (1998) highlight the importance of defensive rebounding as the main factor identifying winning and losing teams. Garcia et al (2013) specifies, that importance of effective defensive rebounding increase in the playoff games relative to the regular season. Karipidis et al. (2010) have studied the coordinated movements before the final effort in the European high-level basketball. The results revealed that: 8 out of 10 of the realized offenses led up to a control offense 5 to 5, while the outside game was dominant, taking up 65% of the executed offenses. One of the most important and frequently used offensive interactions between players are screens. Four out of ten outside game offenses were realized with a screen. The most popular way of co-operation with a screen was pick and roll. Polykratis et al. (2010) have analyzed the alterations of Pick n' Roll effectiveness between the national team of Greece and its opponents during the Mundobasket 2006 in Japan. The results showed statistically significant differences between the Greek and the other National Teams according to the use of Pick n' Roll move in the offensive set plays.

In a series of our previous studies, we were able to work out the basics of the analytical system of the offensive teamwork aspect which has allowed to reveal the structure of the offensive team activity (Bazanov, et al. 2006; 2005) and find out the factors which cause the turnovers of the team and conditions to avoid them (Bazanov and Võhandu, 2009). Furthermore, it has been developed a method of calculating the intensity of offensive teamwork activity, whereby we have found that among non-professional men's basketball team's ball possessions with higher „teamwork intensity" were more successful (Bazanov, B., 2007). Subsequent studies have confirmed these results at a high level of male (Bazanov and Rannama, 2016) and female basketball teams (Bazanov and Rannama, 2015a). However, it has remained unopened a coordinated handling of the playerś physiological load indicators in conjunction with the effectiveness and the technical/tactical aspects of offensive activity in basketball.

Based on this knowledge, the aim of the current study was to identify the players physiological and mechanical load demands in association with the offensive teamwork structure and efficiency at the junior level of basketball performance.

MATERIAL AND METHODS

Sample and data processing

Sixteen elite male junior (age 17,4 ± 1,2 years; height 193,7 ± 7,4 cm; mass 84,4 ± 11,1 kg) Estonian basketball players volunteered to participate in this study. The data were gathered from 197 ball possessions in three videorecorded (Nikon 1 J3) competitive games played in division 1 of Estonian Championship. Further editing of the recorded games was done using the Kinovea 0.8.15 program. The technical/tactical indicators of the team offensive activity, players playing positions, „teamwork intensity" and outcomes were handnotated postevent to the Microsoft Office Excel table. „Teamwork intensity" was determined using the following formula: Index = (D + P + Scr on + Scr off + S) /t, where: D - dribbles; P - passes; Scr on - screens on the ball; Scr off - screens off the ball; S - shot; t - time of ball possession in the offensive zone (Bazanov et al., 2005). The time of ball possession in offensive zone starts from the moment when the player in the offensive zone takes hold of the ball and ends with the moment the ball leaves the hands of the shooter or with the moment when the opposite team possesses the ball. Time is stopped in rebound and inbound situations. The time duration was measured with 0,04 Sec accuracy.

The offensive efficiency coefficient (OEC) was calculated by the equation of D., Oliver (2004) OEC = points/possessions.

The heart rate and mechanical activity values of each player partakes in team ball possession were obtained by the physiological status monitoring device Zephyr™ BioHarness™ (Zephyr Technology, 2003) and synchronized with video recordings. During the game, sensor fixed the different parameters in one-second intervals.

Vector Magnitude Units (VMU) are used to indicate activity level. They are expressed in 'g' - units of gravity, $9.81 m/s^2$.

0.2g - roughly equivalent to a walking level of activity
0.8g - roughly equivalent to a running level of activity

The BioHarness contains a 3-axis accelerometer which can record values of ±16g in the X (subject vertical), Y (subject lateral), or Z (subject sagittal) axes. The data is sampled at 100Hz, and these sets of samples used to calculate

$$\mathrm{VMU} = \frac{1}{n}\sum_{s=1}^{n}\sqrt{(x_s^2 + y_s^2 + z_s^2)}$$

Thus the VMU for the epoch is the average of $\sqrt{(x^2 + y^2 + z^2)}$ calculated for each sample point during the epoch (© Zephyr Technology 2013). Mechanical activity values were categorized according to the game of basketball as follows:

0.20 ... 0.80g - low;
0.81 ... 1.00g - average;
1:01 ... 1.29g - high;
1.30 ... 1.70g - very high.

For all measured functional parameters (heart rate, mechanical activity) was calculated team average values by the following formula: Team value = Sum of pitch players' values/5.

Data analysis
The analysis of aggregated data was done by the means of WizWhy program (data mining) (WizSoft, 2002). The program summarizes the data and presents the main patterns. It meets this target by listing the relations between all the values in each field and the dependent variable. The method employs a unique algorithm that segments numeric fields in an optimal way and displays the relation between each interval and the value under analysis. WizWhy lists the rules that relate between the dependent variable and the other fields. This analysis of the basic rules and trends results in the summary of the data. The rules are formulated as “if-then” sentences. The trend report presents the one-condition relations in the data, and as such it summarizes the data. If-then rules represent sufficient conditions (the “if” condition is a sufficient condition for the result) (Bazanov et al., 2006). The minimum confidence of the if-then rules is equal to 0,56 and if-then not rules is equal to 0,76. Maximum number of conditions in a rule: 3.

Reliability
The observation was made by observer with a high experience in playing and coaching basketball who was trained in the use of the software and the identification of the variables. For the verification of the reliability of collecting data, 39% of all ball possessions were notated on three occasions after a period of two weeks (a

test-retest-retest method). Intra-observer reliability for specific offensive actions and „teamwork intensity“ was determined using a percentage error equation - Percentage error = ∑(mod (S1-S2)) / (∑(Mean S1 + S2)) * 100

Where S1 = Recording set 1, S2 = Recording set 2, mod is the modulus, ∑ = the sum of and '*' = multiplied by (Hughes et al., 2003). Conventional agreed percentage of inaccuracy was set at 5% level. The percentage error differences for Intra-observer reliability of „teamwork intensity“ index between Set 1 and Set 2 and Set 2 and Set 3 were 8.08% and 2.09% respectively, suggesting Set 3 data is more reliable.

RESULTS

The results of summary report showed that the offensive efficiency coefficient was equal to 0,90 on average ((± SD 1,15) with a frequency of 40%. The sample of associative rules for the offensive efficiency coefficient (dependent variable) to be more than the average 0,90 (predicted value) are presented in Tables 1 and 2.

Table 1. The sample of associative relationships between functional indicator (HR) for the offensive efficiency coefficient to be more than 0,90 (average).

Rule Nr	(*if*) conditions			then OEC	*conf. Level*	*error probability*
	1	**2**	**3**			
1	HR 1 167 ... 197 (180)	Lay-Up 1	Index 0,84 ... 1,52 (1,13)	> 0,90	0,9	< 0,00001
2	HR 1 167 ... 197 (181)	Akt. 3 0,71 ... 1,49 (1,05)	Lay-Up 1	> 0,90	0,75	< 0,00001
3	HR 1 167... 197 (181)	Akt. 5 0,66 ... 1,37 (1,00)	Lay-Up 1	> 0,90	0,72	< 0,0001
4	HR 1 167 ... 192 (181)	Jump shot 0	Index 0,83 ... 1,55 (1,09)	> 0,90	0,73	< 0,0001
5	HR 4 180 ... 190 (184)	Lay-Up 1	Index 0,89 ... 1,52 (1,20)	> 0,90	1	< 0,0001
6	HR 3 165 ... 191 (180)	Jump shot 0	Index 0,83 ... 1,55 (1,11)	> 0,90	0,72	< 0,001
7	HR 1 167 ... 192 (180)	Akt. 4 1,20 ... 1,51 (1,30)	x	> 0,90	0,65	< 0,01

"If-then" (> 0,90) rules confidence level minimum 0,56; Act. – mechanical activity; HR – the heart rate (BPM); 1 – point guard; 2 – shooting guard; 3 – small forward; 4 – power forward; 5 – center; (t) – time; OZ – offensive zone; (t) total – total time in possession; Index – „teamwork intensity" value. In table all durations in seconds. in brackets average values.

Table 2. Sample of associative relationships between mechanical activity indicators for the offensive efficiency coefficient to be more than 0,90 (average)

Rule Nr	(*if*) conditions			then OEC	*conf. Level*	*error probability*
	1	**2**	**3**			
1	Act.. 3 0,71 ... 1,49 (1,09)	Lay-Up 1	Index 0,83 ... 1,52 (1,10)	> 0,90	0,91	< 0,0000001
2	Act.. 3 0,81 ... 1,49 (1,15)	(t) OZ 0,71 ... 2,88 (2,09)	Index 0,83 ... 1,55 (1,18)	> 0,90	0,84	< 0,0001
3	Act.. 3 0,71 ... 1,49 (1,12)	Act. 4 1,20 ... 1,49 (1,30)	Index 0,83 ... 1,55 (1,14)	> 0,90	0,87	< 0,001
4	Act.. 4 1,20 ... 1,51 (1,31)	Index 0,83 ... 1,55 (1,13)	x	> 0,90	0,81	< 0,001
5	Act.. 2 1,20 ... 1,61 (1,33)	Index 0,83 ... 1,52 (1,07)	x	> 0,90	0,69	< 0,01
6	Act.. 4 1,20 ... 1,51 (1,32)	(t) OZ 1,23 ... 2,88 (2,15)	x	> 0,90	0,83	< 0,01
7	Act.. 4 1,20 ... 1,51 (1,31)	(t) Total 1,23 ... 6,26 (4,32)	x	> 0,90	0,73	< 0,01
8	Team Act . 1,12 ... 1,37 (1,19)	Index 0,83 ... 1,55 (1,17)	x	> 0,90	0,68	< 0,01

"If-then" (> 0,90) rules confidence level minimum 0,56; Act. – mechanical activity; 1 – point guard; 2 – shooting guard ; 3 – small forward; 4 – power forward; 5 – center;; Team Act – the teams average mechanical activity; (t) – time; OZ – offensive zone; (t) total – total time in possession; Index – „teamwork intensity" value. In table all durations in seconds, in brackets average values.

The sample of associative rules for the team efficiency (depended variable) more than the average 0,90 (predicted value) highlights the role of the point guardś high level of heart rate (181 BMP on average) for increasing the offensive efficiency (Table 1 rule 1-4). Furthermore, the efficient possessions are characterized by the high values of mechanical activity (>1) and heart rate (165-191 BMP) of forwards accompanied by a high „teamwork intensity" indicator (Table 2, rules 1-5).

DISCUSSION

The purpose of the current study was to identify the players physiological and mechanical load demands in association with the offensive teamwork structure and efficiency at the junior level of basketball performance.

The analysis of competitive game activity in coordination with the players physiological and mechanical load demands was needed to discover main conditions associated with the basketball team offensive efficiency. Results show, that the average value of the offensive efficiency coefficient and "teamwork intensity" indicator was 0,90 (± SD 1,15) points and 0,78 (± SD 0,27) respectively. The offensive efficiency coefficient (OEC) is considered to be one of the main indicators in basketball. Usually the average OEC is equal to 1,0 (Oliver, D., 2004). Thus the efficiency of the team under analyses may be considered as slightly lower than needed.

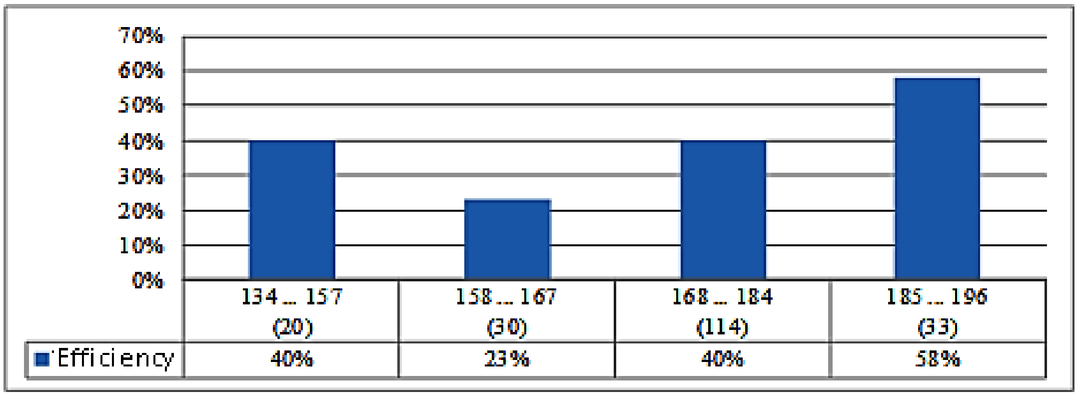

Figure 1. Main patterns related between team average values of HR and offensive efficiency

Figure 1 illustrates the analyzed team`s heart rate values in association with offensive efficiency indicator. Prior to it must be stated that the average percentage of the team`s offense that ended successfully was 40%. All possessions (N = 197) are grouped according to the heart rate. On the figure we can see that the majority of offenses (114) has the team's heart rate value between 168 – 184 BPM, which highlight the high physiological intensity of offensive activity in basketball. The main offensive method is considered to be set offense (Tavares and Gomes, 2003). On this basis, we can assume that also in our study the greatest number of possessions belongs to set offenses. The aforementioned heart rate interval coincides with the average values indicated in earlier studies (McInnes et al., 1995; Hůlka et al., 2013; Apostolidis et al., 2004; Abdelkrim et al., 2007). However, the average heart rate values measured in these studies do not link to a specific offensive phase and efficiency. The results of the current investigation are opening the sufficient conditions to attain higher efficacy indicator. The main pattern highlighted on the figure 1 show, that the highest frequency of offensive efficiency (58%) associated with the highest (185-196 BPM) teamś heart rate value. The list of if-then rules clarifies, that the teamś offensive efficacy is higher in successful possessions with high "teamwork intensity" indicator (0,83 ... 1,55) accompanied by high heart rate of point guards (167 ... 192) and forwards (165 ... 191) (See table 1). "Teamwork intensity" is one of the factors influencing the efficiency in basketball (Bazanov et al., 2005). Comparison of resultive and non-resultive possessions at non-professional (Bazanov et al., 2005), high male (Bazanov and Rannama, 2016) and female (Bazanov and Rannama, 2015) basketball performance indicates, that with the growing of the "teamwork intensity", as a rule, increases the offensive efficiency. One of the main factors, influencing the „teamwork intensity" in basketball is time in possession (Bazanov et al., 2006). Observation of competitive activity at a high level of basketball performance convince, that the modern game is becoming more dynamic. For example, some studies show that the duration of fast breaks has decreased from 5,15 seconds, found by Cardenas et al. (1995) to 3,84 seconds highlighted by Bazanov and Rannama (2016).

In current study timing values as contained in the sufficient conditions (Table 2 rule 6, 7) binds with high offensive efficiency, typical of fast-break situations. The highest efficiency in these offencies is accompanied with high "mechanical activity" of the shooting guards and forwards, which point to the increased requirements of special functional preparation of players playing in these positions. Efficiency is reduced with decreasing of mechanical activity indicator (see figure 2).

The results of the study carried out by Bazanov and Rannama (2015) show, that ball possessions to higher offensive „teamwork intensity" value are more effective also at a high level of European junior basketball performance. The results of this study confirm those statements providing additional objective information related to the physiological and mechanical load of the players.

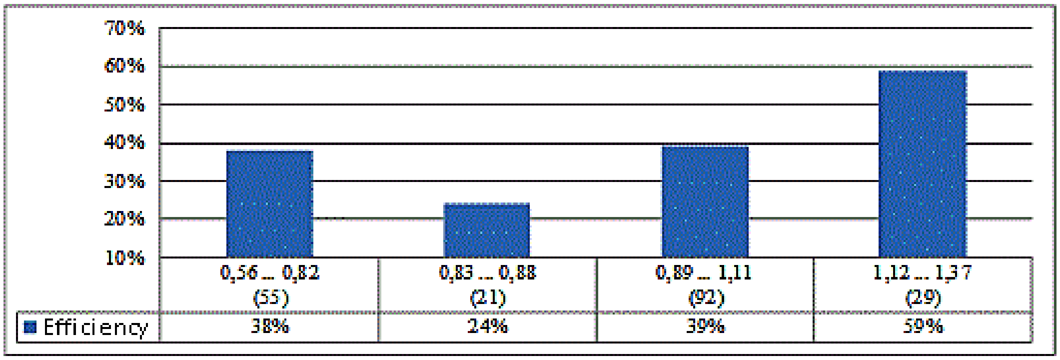

Figure 2. Main patterns related between team average values of mechanical activity and offensive efficiency.

CONCLUSIONS

Based on the results of this study, we can state that the offensive efficiency in basketball grows with the increase of the offensive „teamwork intensity", accompanied by the rising in physiological and mechanical load values of especially guards and forwards.

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