INTENSITY IN PROFESSIONAL BASKETBALL LEVEL MATCHES: AN APPROACH USING TOTAL TIME AND LIVE TIME SITUATIONS

INTENSIDAD EN LOS PARTIDOS DE BALONCESTO A NIVEL PROFESIONAL: UN ENFOQUE UTILIZANDO SITUACIONES DE TIEMPO TOTAL Y TIEMPO EN VIVO

INTENSIDADE EM JOGOS DE BASQUETEBOL NO NÍVEL PROFISSIONAL: UMA ABORDAGEM USANDO SITUAÇÕES DE TEMPO TOTAL E TEMPO AO VIVO

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ABSTRACT

The objective of this study was to characterize the basketball intensity in official matches through players' heart rate during professional level competitions. Ten players in six games were analyzed. The quantification of time spent in each zone was based on %HRmax recorded for each player in each quarter played. The first quarter presented a HR response of 169.9 beats.min-1 during the total time and 173.5 beats.min-1 during active time. The relative values in the first quarter for both the total and active time were 92.5% and 94.0% HRmax, respectively. The highest HRmax zones presented longer predominance in comparison to other HRmax zones. It is recommended the prescription of higher intensities to the lower level leagues. The application of intermittent exercise, with an individual intensity between areas of moderate intensity and high HR%, may be interesting.
KEYWORDS: Sports Medicine, Heart Rate, Exercise.

RESUMEN

El objetivo fue caracterizar la intensidad de partidos oficiales de baloncesto desde la frecuencia card aca de los jugadores en competiciones de nivel profesional. Se analizaron 10 jugadores de baloncesto de lite masculinos, en seis partidos oficiales durante la temporada regular de la liga profesional. La cuantificaci n del tiempo gastado en cada zona se bas en el porcentaje de FCmax registrado para cada jugador en cada cuarto jugado. El primer cuarto present una respuesta de FC de 169,9 lat.min-1 durante el tiempo total, y 173,5 lat.min-1 durante el tiempo real. Los valores relativos en el primer cuarto, tanto en el tiempo total como el tiempo real, fueron 92,5% y 94,0% de FCmax, respectivamente. Las zonas de FCmax de mayor intensidad presentaron predominancia superior, en comparaci n con otras zonas de FCmax. La implicaci n pr ctica es prescribir ejercicios de mayor intensidad que los que se presentan durante los juegos de ligas de nivel inferior. Un programa de entrenamiento podr a ser interesante si se enfoca en la aplicaci n de ejercicios intermitentes con intensidad individual desde zonas de FC moderadas a las m s altas.

PALABRAS-CLAVE: Medicina Deportiva, Frecuencia Card aca, Ejercicio.

RESUMO

O objetivo foi caracterizar a intensidade dos jogos de competiç o de basquetebol por meio da frequ ncia card aca dos jogadores nas competiç es profissionais. Analisaram-se 10 jogadores em seis jogos. A quantificaç o do tempo de perman ncia na cada rea baseia-se no valor de FCmax recolhidos para a cada jogador na cada quarto jogado. O primeiro quarto apre-

sentou respostas da FC de 169,9 bat.min -1 durante o tempo total e 173,5 bat.min -1 durante o tempo ativo. Os valores relativos para o primeiro quarto, tanto para o tempo total como o ativo, foram 92,5% e 94,0% de FCmax, respectivamente. A zona FCmax de maior intensidade mostrou maior preval ncia em comparaç o com outras zonas. Recomenda-se prescrever intensidades superiores s s ries de campeonatos de n vel inferior. O aplicativo do exerc cio intermitente, com uma intensidade individual entre as zonas de intensidade moderada e alta de HR%, pode ser interessante.

PALAVRAS-CHAVE: Medicina Esportiva, Frequ ncia Card aca, Exerc cio.

INTRODUCTION

In basketball, understanding the intensities which elite athletes are exposed during official games is considered very important for coaches and support staff. This is essential because the main aim of physical preparation is better performance on the court. The use of objective parameters helps physical trainers support staff to prescribe training without excessive load during training sessions. In basketball, many studies have been made to study these intensities. There is some studies that has been included external load parameters analysis, quantifying variables of movement frequencies using time motion analysis (Abdelkrim *et al*., 2007; McInnes *et al*., 1995; Scanlan *et al*., 2012)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D..

On the other hand, other studies had adopted internal load parameters analysis, performed by a quantification of rated perceive exertion (RPE), blood lactate concentration and heart rate (HR) in its absolute and relative values as the percentage of maximal HR value (% HRmax) (Abdelkrim *et al.*, 2007; Narazaki *et al.*, 2009; Rodr guez *et al.*, 2003; Scanlan *et al*., 2012)".

The HR in particular shows the intensity with which players are involved during games. These are very high during most time on the court, especially during live time situations. Players have HR response levels above 85% HRmax over 75% of the game (McInnes *et al.*, 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing

time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. In addition, they have means of 91% (Abdelkrim *et al.*, 2007) and 90.8% (Rodr guez *et al.*, 2003) of HRmax during total time. Some authors have investigated HR response during basketball games (Abdelikrim *et al.*, 2009; Abdelkrim *et al.*, 2007; Hůlka *et al.*, 2013; Matthew & Delextrat, 2009; Rodr guez *et al.,* 2003).

However, there are still relatively few investigations that have tried to analyze the HR response of male players during official professional level games or in other more competitive categories. Analyses made in u-19 games shows that player's competitive level has a direct influence on the effort intensity during an official game (Abdelkrim *et al.*, 2010)053 vs. 1,056 and 253 vs. 224, respectively, $p > 0.05$. Hence, analysis of the effort intensity in professional competitions is important because it can explain the results of training and prescribe improved training methods to achieve elite status.

The HR data collected during the game and the time spent in several HRmax zones for both total and live time allows coaches and support staff to better prescribe training intensity. This may improve training quality and the physical capacity of the players while elevating their competitiveness that of a professional level team. Therefore, the main aim of this study was characterizing the basketball intensity in official matches from players' heart rate during professional level competitions.

The specific objectives were to: a) Determine the time spent by players in six HRmax zones; b) Describe the aspect of HR response among quarters and halves; and c) Distinguish the time spent among HR zones during total time and live time for HR while comparing the data to other studies with competitions from other categories and levels. Our hypothesis is that professional level player's HR data is more predominant in the maximal and high HRmax zones and that the live time situation in these level of matches is more intense than total time situation.

METHODS

The ethics board of the University approved the research and all subjects involved gave their consent by signing their respective consent terms, being allowed to withdraw in anytime of research process. The HR samples were collected from 10 male elite basketball players during six official matches in the regular season of the Brazilian professional basketball league (NBB). The HR was recorded using a heart rate monitor Polar®, Team System model with a sample frequency of 0.2 Hz (HR information every 5 s).

Minutes before each game began, all 10 players involved in the study were fitted with the HR monitor Team System (Polar, Kempele, Finland). As soon as the HR monitor was fitted in the player, a chronometer was used to record the game time for a further synchronization of HR data recording with the starting time of the match. Besides the game's beginning, the amount of time on the court was recorded for each player. At the end of the match, the HR data were stored on a personal computer. It was then separated according to the time that the players spent on the court.

After storage of HR data, play time in each zone was quantified based on %HRmax recorded for each player for each quarter played. The HR zones was defined according to the zones proposed in a previously study, also performed with basketball players (McInnes *et al*., 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. The HR zones were defined as Z1 (<74% of HRmax), Z2 (75-79% of HRmax), Z3 (80-84% of HRmax), Z4 (85-89% of HRmax), Z5 (90-94% of HRmax), and Z6 (>95% of HRmax). This classification was

adopted for a better comparison to others studies that also have quantified the time spent in the zones by the same criteria (Abdelkrim *et al.*, 2007; Hůlka *et al.*, 2013).

The median HR response for all quarters and halves for all players on the court were also calculated. The data was analyzed for both the total time and the live time situation. The total time was defined as the time spent on the court during games including when the game clock was stopped. This includes free throws and time outs whereas the live time was the effective play time and included periods when the game clock was running. The statistical procedures were performed with MatLab® software using the Kolmogorov Smirnov test for normality assessment followed by a Kruskal Wallis test for comparison among groups and a Tukey's post hoc test for identification of differences. The median was calculated for all dependent variables, and the significance level was set to $P < 0.05$.

RESULTS AND DISCUSSION

The results of absolute and relative HR response medians in each half and quarter are presented in Table 1 for the Total Time and the Live Time situations. For absolute HR values during total time, the first quarter presented a HR response of 169.9 beats.min-1, which was the higher median found among all quarters. During live time, players also have higher medians in the first quarter (173.5 beats.min-1) than in the other three. The relative values also presented higher values in the first quarter in both total time and live time situations (92.5% and 94.0% HRmax, respectively).

Table 2 presents the absolute and relative time spent in each %HRmax zone for both total and live time. The highest HRmax zones (90-94% and >95% of HRmax) presented longer predominance in comparison to other HRmax zones. During total time,

Table 1. Medians of HR and %HRmax values in each quarter, halves, and the entire game for total time and live time situations. *Significant difference versus live time.

	Total Time (TT)		Live Time (LT)	
	HR (beats·min-1)	%HRmax	HR (beats·min-1)	%HRmax
Quarter 1 (Q1)	169.9*	92.5	173.5	94.0
Quarter 2 (Q2)	159.5*	90.9*	166.3	93.1
Quarter 3 (Q3)	163.4*	90.6*	166.2	91.5
Quarter 4 (Q4)	146.8*	85.6	157.0	89.7
Comparison (Quarters)	Q1>Q3>Q2>Q4	Q1>Q2=Q3>Q4	Q1>Q2=Q3>Q4	Q1>Q2=Q3=Q4
Half 1 (H1)	164.8*	91.8	171.2	93.6
Half 2 (H2)	156.1*	88.3*	163.2	90.9
Comparison (Halves)	H1>H2	H1>H2	H1>H2	H1>H2
Game	160.7	90.2	167.5	92.6

the time spent in Z5 and Z6 zones were 169.2 s (26%) and 176.7 s (28.7%), respectively. The same predomination was observed in the live time situation, the individual HR response was predominant in the highest HRmax zones. It was 96.0 s (27.1%) and 103.0 s (35.9%) of the time played.

The quantification of time spent in the %HRmax zones describes the aerobic and anaerobic players' performance, especially in elite professional players. Thus, the main finding of this study is that official professional level games involve an intermittent change in intensity, but these are still the highest HRmax zones measured relative to other competitions studied previously during live time. Furthermore, there is a lower HR response in the lowest %HRmax zones during total time versus other competitions.

Table 2. Median time spent in each %HRmax zones during total time and live time.

Time spent		**Z1** <74% HRmax	**Z2** 75-79% HRmax	**Z3** 80-84% HRmax	**Z4** 85-89% HRmax	**Z5** 90-94% HRmax	**Z6** >95% HRmax	**Comparison**
TT	s	52.9	37.0	66.1	103.5	169.3	176.7	Z6=Z5>Z4>Z3=Z1>Z2
	%	7.5	5.1	8.4	14.4	26.0	28.7	Z6=Z5>Z4>Z3=Z1>Z2
LT	s	1.6	7.9	17.9	43.1	96.1	103.0	Z6=Z5>Z4>Z3>Z2=Z1
	%	0.5	2.2	5.7	11.9	27.1	35.9	Z6=Z5>Z4>Z3=Z2=Z1

Although other studies (Abdelkrim *et al.*, 2010; Klusemann *et al.*, 2013; McInnes *et al.*, 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D. have reported great means of HR values{Klusemann, 2013, Activity profiles and demands of seasonal and tournament basketball competition} {Klusemann, 2013, Activity profiles and demands of seasonal and tournament basketball competition}, they were lower than the medians found here for the maximal HRmax (>95% HRmax). Moreover, our results show that the time spent in the Z5 and Z6 zones were significantly greater than those quantified for other %HRmax zones. These were more than 54% and 63% for both the highest zones during total time and live time, respectively.

According to the literature (Abdelkrim *et al.,* 2010)053 vs. 1,056 and 253 vs. 224, respectively, p > 0.05, the time spent in the different %HR zones might be associated with a team's playing styles. A basketball game is characterized by a variation of intensities, it is a team sport with intermittent efforts. Our findings suggest that the intensity of professional male basketball official games is more intense than other competitions reported in the literature. The intensity was maximally increased in the maximal zone (>95% HRmax) during these games.

The median of the absolute values in HR responses in the entire game was 167.5 and 160.7 beats·min-1 during live time and total time, respectively. The value during live time is closely similar to that found in previous basketball studies (Matthew & Delextrat, 2009; McInnes *et al.*, 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during

competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. However, some studies reported means of 162 ± 3 beats·min-1 (Scanlan et al., 2012)total durations and total distances were determined for various activity categories. Results: Mean (??SD, which is lower than the median during live time reported in our investigation. In addition, there are studies that presented values of 171 beats·min-1 during total time (Abdelkrim *et al.*, 2007). Although has been a study performed with under-19 players, the data reported in Tunisian athletes is much higher than the median during total time in our subjects. This might suggest a great variation among competitions on intensity levels and a difference in time spent during recovery, this contributes to a HR decrease (McInnes *et al.*, 1995; Daniel *et al.*, 2013)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. This difference could also be explained by age (Abdelkrim *et al.*, 2007) and players gender difference (Scanlan *et al.*, 2012)total durations and total distances were determined for various activity categories. Results: Mean (??SD.

According to Matthew & Delextrat (2009)heart rate was recorded continuously, and blood samples were collected to determine blood lactate concentration when the competition rules allowed. The main results showed that the players performed on average 652 +/- 128 movements per game, which corresponded to a change in activity every 2.82 s. Mean heart rate was 165 +/- 9 beats . min(-1, the literature has many variations in terms of HR response between halves during team sports. In basketball, some studies have suggested that a mean HR response

during the first half is higher than that in the second half (Matthew & Delextrat, 2009)heart rate was recorded continuously, and blood samples were collected to determine blood lactate concentration when the competition rules allowed. The main results showed that the players performed on average 652 +/- 128 movements per game, which corresponded to a change in activity every 2.82 s. Mean heart rate was 165 +/- 9 beats . min(-1 and through quarters (Abdelkrim *et al.*, 2007). Others reported no significant difference in their data (Rodr guez *et al.*, 2003). However, our results showed HR responses in line with those reported in the literature for both absolute and relative values with a median corresponding to 164.8 beats·min-1 (91.8% HRmax) and 156.1 beats·min-1 (88.3% HRmax) for the first and second halves, respectively, during total time. This great reduction observed between halves could be explained by the influence of the fourth quarter in which the median is much lower than the other quarters for both total and live time.

Indeed, the literature shows that the fourth quarter generally is less demanding in terms of high intensity activities. This is because of more timeouts and free throws (Abdelkrim *et al.*, 2007), which facilitates player recovery (McInnes *et al.*, 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. Hence, even with the differences in competitions and player's levels, the median HR response obtained here suggests that the dynamic effort expended among halves and quarters in professional basketball games has a similar behavior to those reported in other basketball competitions.

As expected, the %HRmax values obtained in the present study during live time was higher than in total time. The median

was 92.6% vs 90.2% of HRmax in whole game. The median of 90.2% HRmax during the game, in total time situation, was slightly higher than the mean of 89.1% HRmax for female players in a national competition (Matthew & Delextrat, 2009)heart rate was recorded continuously, and blood samples were collected to determine blood lactate concentration when the competition rules allowed. The main results showed that the players performed on average 652 +/- 128 movements per game, which corresponded to a change in activity every 2.82 s. Mean heart rate was 165 +/- 9 beats . min(-1. It was also slightly lower than the values of 91% of HRmax recorded from under-19 Tunisian players (Abdelkrim *et al*., 2007) and 90.8% of HRmax from female players in a national level competition (Rodr guez *et al*., 2003). The measurement of HR response during total time and live time is an interesting way to study player intensity in two different conditions in the game. As observed here, there is a great difference on HR response between these two situations. This is explained by the high intensity activities that are performed in live time that reflect the truly physiological involvement during the game (Matthew & Delextrat, 2009)heart rate was recorded continuously, and blood samples were collected to determine blood lactate concentration when the competition rules allowed. The main results showed that the players performed on average 652 +/- 128 movements per game, which corresponded to a change in activity every 2.82 s. Mean heart rate was 165 +/- 9 beats . min(-1. In addition, it is important to consider that there are individual differences among players. This leads to several levels of aerobic fitness and reflects different absolute HR responses under a similar effort intensity (McInnes *et al*., 1995) the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total

time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D..

It is interesting to measure the percentage of maximal HR response that each player presents when they are facing greater physical demands. In the literature, the measurement of HR response is based on the individual maximum values (HRmax). These have been adopted by many studies with basketball players (Matthew & Delextrat, 2009; McInnes *et al.*, 1995; Narazaki *et al.*, 2009; Rodr guez *et al.*, 2003; Scanlan *et al.*, 2012)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D. to avoid an incorrect assessment of internal load in players. Hence, based on the results of HRmax response from players, we suggest that there is a higher intensity during live time than during total time at the individual level, similar to other competitions. This led us to consider that professional level players also need specific training to be prepared for a higher level of intensity during live time.

The difference between total time and live time situations is according to what was reported in other studies. However, considering the relationship of competition level and HR response, these results indicate that the intensity experienced by players in professional male competition may be similar to female UK players at the national level (Matthew & Delextrat, 2009)heart rate was recorded continuously, and blood samples were collected to determine blood lactate concentration when the competition rules allowed. The main results showed that the players performed on average 652 +/- 128 movements per game, which corresponded to a change in activity every 2.82 s. Mean heart rate was 165 +/- 9 beats . min(-1 and more intense than Tunisian

under-19 male competition games with a mean of 91.0% of HRmax (Abdelkrim *et al*., 2007). The literature shows that the mean of HRmax during live time ranges from 89% to 92.5% of HRmax (Matthew & Delextrat, 2009; McInnes *et al*., 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D. suggesting a variation of intensities that are related to the level of competition, playing standard of teams and physical fitness of players.

The time spent in several HRmax zones also presents the same difference when compared between total time and live time situations. The maximal zone (>95% HRmax) was higher during live time than total time (35.9% vs 28.7%). The same happened with the high intensity zone (90-94% HRmax), where the time spent was 27.1% and 26.0% during live time and total time, respectively. The time spent in maximal intensity HR zones is greater than the values of 17.8% and 15.2% of live time spent by National and International u-19 players (Abdelkrim *et al*., 2010)053 vs. 1,056 and 253 vs. 224, respectively, $p > 0.05$, but much lower than values of 59.1% and 54.4% of live time spent in high intensity zones by players in the same study.

This great difference between the findings may be explained by the different HRmax zones division criteria adopted. Whereas the zones in our investigation was divided into six zones, the previously study adopted a division into four HRmax zones, which caused a wider range (10 beats.min-1) than our study for time spent quantification in each HRmax zones. The findings reported by a study with Czech national basketball players (Hůlka *et al*., 2013) for maximal HR zones (14.01%) were lower than the resulted presented here, for during live time (35.9%) and

total time (28.7%). When compared the high intensity HRmax zones, the values presented by the previously study (28.08%) is slightly higher than our results for live and total time situations (27.1% and 26.0%). This suggest that players at professional level competition may be exposed to more physiological demanding activities than what is usually found in other lower competitive level games.

Moreover, the data presented in a study with Spanish athletes (Rodr guez *et al.*, 2003) clearly highlight the difference of physiological demand between different games levels. These have reported a greater mean of %HRmax for international versus national games. Another aspect that must be mentioned is that our data may be related to the game's intensity increase that occurred after rule changes in the 2000s. These were influenced by the ''8–24 s rule'' (Abdelkrim *et al.*, 2007) that has contributed to the median obtained in our study being considerably higher than the mean of 89% HRmax during live time in games analyzed before rule's change (McInnes *et al.*, 1995)the intensities of activity and movement patterns during men's basketball were investigated by videoing the movements and monitoring the heart rate and blood lactate responses of eight elite players during competition. The results are expressed according to 'live time', which is actual playing time, and 'total time', which includes live time as well as all stoppages in play. The mean (plus/minus S.D.. Therefore, the intensity level of professional basketball games seems to be higher even when considering individual differences. The HR response found in our study is in the highest zones for a longer time than what was reported in literature in other competitions.

CONCLUSION

The practical implications for coaches and support staff should be to prescribe higher intensity exercises than what is usually

presented during games for lower level leagues. More time should also be spent on recovery. It has great importance in training for male professional level basketball players (Daniel *et al.,* 2013). In addition, it could be interesting to adopt a training program more focused on the application of intermittent exercises with individual intensity ranges from high to maximal HR zones (85-89% to >95%HRmax zones). This is important because the HR response is normally in the highest zones during official, professional games.

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