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# Heart rate responses of referees during the 2011 Eurobasket Championship

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## ABSTRACT

Vaquera, A., Renfree, A., Thomas, G., St Clair Gibson, A., & Calleja-González, J. (2014). Heart rate responses of referees during the 2011 Eurobasket Championship. *J. Hum. Sport Exerc.*, 9(1), pp.43-48. The purpose of the study was to describe heart rate responses of referees during a major international basketball championship. Heart rate (HR) data was collected from 26 international referees officiating 48 matches (95 matches 'worth' of data) at the 2011 Eurobasket Championship. HR was subsequently normalised to percentage of theoretical maximum, and used to calculate time spent in different exercise intensity zones (Light, moderate, heavy, very heavy) across successive phases of the tournament and successive quarters (Q) of matches. Mean HR was  $81.89 \pm 13.4\%$  of theoretical maximum during match play, and there were no significant differences in HR recorded during different phases of the championship. However, relative HR progressively decreased with each quarter of the matches (Q1;  $91.43 \pm 7.6\%$ , Q2;  $90.51 \pm 7.1\%$ , Q3;  $88.23 \pm 7.3\%$ , Q4;  $88.21 \pm 7.5\%$  HRmax). This decrease in %HRmax recorded relative to Q1 reached statistical significance ( $P < 0.05$ ) in Q3 and Q4. Although percentage of total match time spent in 'hard' and 'light' exercise intensity categories remained similar across quarters of matches, there was a reduction in time spent in 'very hard' activity from  $10.93 \pm 16.08\%$  in Q1 to  $5.73 \pm 10.36\%$  in Q3 and  $5.55 \pm 10.74\%$  in Q4 (both  $P < 0.05$ ). This reduction in 'very hard' activity was accompanied by an increase in 'moderate' intensity activity from  $15.06 \pm 14.29\%$  in Q1 to  $23.37 \pm 17.12\%$  in Q3 and  $24.35 \pm 20.31\%$  in Q4 (both  $P < 0.01$ ). The data suggests that international basketball referees are unable to maintain initial exercise intensity for four successive quarters of championship play. This is in contrast to available data suggesting elite players are able to maintain or increase exercise intensity as matches progress. This has implications for the physical conditioning requirements of international level match officials. **Key words:** OFFICIATING, DECISION MAKING, CONDITIONING.

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## INTRODUCTION

Despite the availability of published literature relating to the physiological responses of elite level basketball players to game play (Ben, 2007; Vaquera et al., 2008; Stojanovic et al., 2012) there is a paucity of information relating to the physiological responses of referees officiating elite level basketball matches. This is perhaps surprising given the degree to which decision making by officials has the ability to influence final competitive outcomes. Previous work by Royal et al. (2006) has demonstrated that decision making quality by players in a different team sport (waterpolo) varies with exercise intensity. It appeared that the accuracy of decisions made reduced as players progressed from a state of rest to light and moderate intensity exercise, but then improved again as players approached conditions of very high exertion. This was hypothesised to be the result of heightened event specific arousal. It should be acknowledged that these findings differ to other studies that have suggested that cognitive function is impaired under conditions of physical stress (McMorris & Keen, 1994; McMorris & Graydon, 2000), but these studies have used recreational as opposed to highly trained athletes. Given that, even at the international level, basketball officials tend to be significantly older than the players, it would seem plausible that they may possess inferior physical capacities and that accumulated fatigue could influence their ability to effectively monitor on-court activities and make complex cognitively demanding decisions.

The only previously published work we were able to find relating to physiological responses of referees (6 male and 1 female) during match play examined heart rate responses during a pre-Olympic women's tournament (Leicht, 2008). Given that Ziv & Lidor (2009) have reported that elite male basketball players display increased aerobic capacity values compared to female players, it is by no means certain that the physiological responses in a group of male referees officiating an international male tournament will be similar to those in a group of (predominantly) male referees officiating a female tournament. This study examined physiological responses in a group of international referees during match play at a major international basketball championship to determine whether physical activity levels were maintained throughout the course of matches.

## MATERIAL AND METHODS

Personal and anthropometrical data was collected from 26 referees officiating 48 matches at the 2011 EuroBasket Championship staged in Lithuania. All procedures utilised in this study had prior approval of the Ethics Committee at the University of Leon, and all participants completed a health screening questionnaire and provided informed consent prior to commencement of the study which conformed to the Declaration of Helsinki.

Twenty four national teams participated after securing qualification through either an initial qualifying round or participation in the 2010 FIBA World Championships. The tournament comprised three 'phases' with qualification to each subsequent phase being based on performance in the previous one. Although three referees officiated each match, for the purposes of this study we were able to collect a total of 95 full matches 'worth' of data (65.9% of total officiating performed over the duration of the championship).

Body composition was assessed through determination of the sum of 6 skinfolds (Marfell-Jones et al., 2006), and these measurements were then used to predict percentage body fat using the formula  $\% \text{ Fat} = 3.64 + (\sum 6 \text{ skinfolds (mm)} \times 0.097)$  (Yuhasz 1974). Heart rate (HR) data was collected throughout each match at 5s intervals via radio telemetry using Suunto Memory Belts (Vantaa, Finland) operating on a secure 2.4 GHz frequency which recorded data on an integrated memory chip for later analysis. Data

collected during stoppages in play was excluded, and mean values were calculated for each quarter of the match. Match durations were recorded using the electronic stopwatch function built into the Suunto units. HR data was subsequently normalised to percentage of theoretical maximum heart rate (ACSM 1995). In order to determine the relative distribution of exercise intensities throughout the matches, we also calculated the percentage of activity time in each quarter spent within the different exercise-intensity categories described by the ACSM (1998) and also used by Leicht (2008). The categories were 'Very hard' (>90% HRmax), 'Hard' (70-89% HRmax), 'Moderate' (55-69% HRmax) and 'Light' (35-54% HRmax).

Data was expressed as mean + standard deviation, and analysed using the SPSS v19 software package (SPSS Inc., Illinois USA). One way Analysis of Variance followed by the Bonferroni post hoc test when appropriate was used to identify differences in mean heart rate recorded during different phases of the competition, and also between different quarters of matches. In order to identify any potential influence of body composition on the ability to sustain relative exercise intensity, referees were split into two equal sized groups ('High fat' and 'Low fat') based on predicted percentage body fat. The magnitude of the change in mean heart rate recorded between Q1 and Q4 was calculated for each referee in every match, and a T-test for independent samples was used to assess differences between groups. Statistical significance was accepted at the  $P < 0.05$  level.

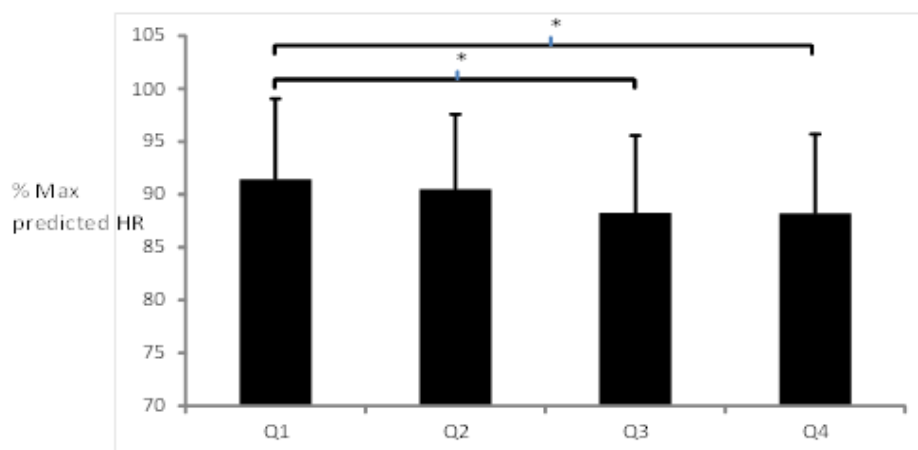
## RESULTS

The physical characteristics of the referees were age:  $39.7 \pm 4.6$  years, height:  $1.79 \pm 0.06$  m, mass:  $82.96 \pm 6.7$  kg, body fat:  $17.57 \pm 3.2\%$ . Mean experience of officiating was  $21.1 \pm 5.0$  years, with  $10.9 \pm 3.9$  years officiating at the international level.

Mean duration of match play across the entire tournament was  $140.3 \pm 11.1$  min, with no significant differences being found between championship phases. ( $143.9 \pm 10.7$  min phase 1;  $138.4 \pm 11.1$  min phase 2;  $136.4 \pm 11.5$  min phase 3). There were however differences in the mean total duration of each quarter of the matches (Q1;  $20.2 \pm 2.1$  min, Q2;  $22.8 \pm 2.1$  min, Q3;  $21.9 \pm 2.2$  min, Q4;  $23.8 \pm 3.3$  min) (all  $P < 0.001$  other than  $P = 0.037$  between Q2 and Q4, and NS between Q2 and Q4).

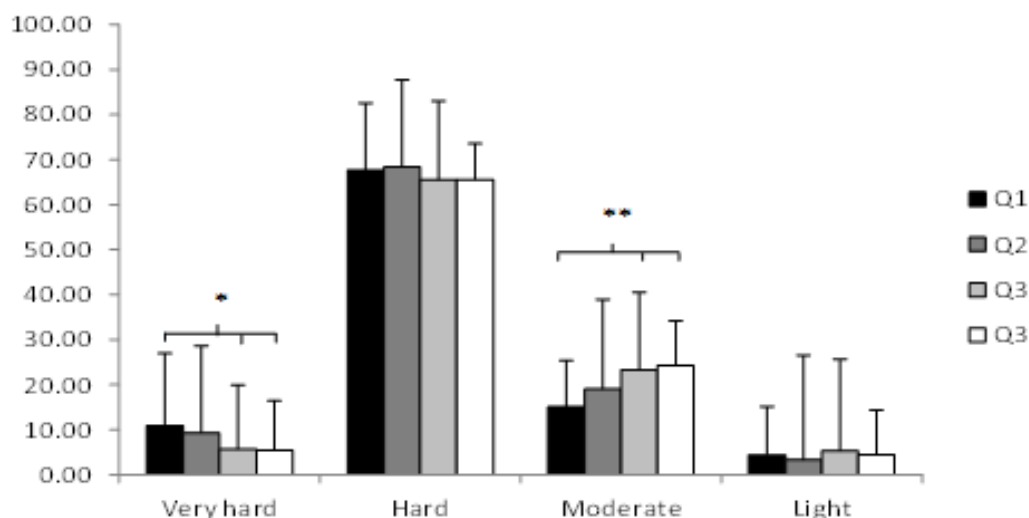
Overall, mean HR during in play periods was  $81.89 \pm 13.4\%$  of the theoretical maximum, and there were no differences between phases (phase 1;  $82.3 \pm 10.1\%$ , phase 2;  $84.1 \pm 7.6\%$ , phase 3;  $84.4 \pm 4.1\%$ ).

Analysis of HR across quarters of the matches revealed that there was a trend for relative HR to decrease as matches progressed. There was a significant ( $P < 0.05$ ) decrease in relative HR in quarters 3 and 4 relative to quarter 1 (figure 1).



**Figure 1.** Mean HR recorded from referees during successive Quarters in EuroBasket 2011 matches:  
\*Significant difference ( $p < 0.05$ ) between quarters

In addition to the decrease in mean HR across successive quarters of the matches, there was also a change in the distribution of total game time spent in the different intensity categories (figure 2). Although there were no significant differences found in the percentage of time spent in the 'hard' and 'light' categories, the percentage of time spent in the 'very hard' category decreased from  $10.93 \pm 16.08\%$  in Q1 to  $5.73 \pm 10.36\%$  in Q3 ( $p = 0.043$ ) and  $5.55 \pm 10.74\%$  in Q4 ( $p = 0.033$ ). This reduction in 'very hard' activity is seemingly achieved as a result of an increase in the time spent in the 'moderate' category from  $15.06 \pm 14.29\%$  in Q1 to  $23.37 \pm 17.12\%$  in Q3 ( $p = 0.007$ ) and  $24.35 \pm 20.31\%$  in Q4 ( $p = 0.002$ ).



**Figure 2.** Percentage of each quarter spent in each intensity category (\* $p < 0.05$ , \*\* $p < 0.01$ )

When changes in the mean HR between Q1 and Q4 were assessed, it was found that the magnitude of the reduction was greater ( $4.4 \pm 4.65\%$ ) in the 'High fat' group than in the 'Low fat' group ( $2.2 \pm 4.75\%$ ) ( $p = 0.046$ ).

## DISCUSSION

The main findings of this study have several potentially important implications for referees of international level basketball competitions. The mean heart rate of  $81.89 \pm 13.4\%$  of the theoretical maximum that was recorded during periods of play is substantially lower than reported values from professional players during match-play (Vaquera et al., 2008), suggesting that the referees were operating at a lower relative exercise intensity. Although it is possible that this could simply be because the physical demands of officiating are not as high as for playing, it should also be emphasised that whereas referees in this study demonstrated a reduction in relative heart rate across successive quarters of the matches, this is in contrast to the previously reported finding that players display an increase in relative HR as matches progress (Vaquera et al., 2008).

This is important, as it suggests that not only are referees operating at a lower relative exercise intensity than players from the outset of a match, but also that either they are unable to maintain this intensity throughout the entire duration of a match, or else they made a strategic choice not to. The difference in relative intensity displayed by referees and players therefore increases as matches' progress, with the greatest discrepancy occurring in the final quarter. It is also apparent that the relative HR values recorded in this study are higher than those reported in an international women's tournament by Leicht (2008), thereby suggesting that the physiological strain imposed by officiating may be greater in male tournaments, possibly due to the greater physiological capacities of elite male players (Ziv and Lidor, 2009).

The change in the relative distribution of time in the various exercise intensity categories as the match progresses is of particular interest, as it suggests that referees compensate for a reduction in the ability to perform 'very hard' activity by increasing the amount of time they spend in 'moderate' activity. This is a relevant finding from the perspective that Royal et al. (2007) have demonstrated that, in elite sport players, the quality of decision making is reduced during periods of moderate activity compared to during periods of light or heavy activity. This suggests that as matches progress referees spend increasingly more time at an intensity of exercise associated with potentially reduced decision making abilities. If this is the case, then it may be expected that officials would be more likely to make erroneous decisions in the final stages of matches.

Also of interest is the apparent relationship between body composition and ability to maintain exercise intensity throughout the entire duration of matches. Although it is acknowledged that predicted percentage body fat is a somewhat limited method of assessing the level of physical conditioning of referees, this finding does suggest that conditioning is an important determinant of the ability to maintain work rate throughout the duration of a match. In light of the previous discussion regarding the potential relationship between exercise intensity and quality of decision making, it may therefore also be the case that the level of conditioning could be expected to influence the ability of referees to effectively officiate, particularly in the latter stages of matches.

## CONCLUSIONS

It can be concluded that during the 2011 Eurobasket Championship, match referees displayed a lower relative exercise intensity than previously reported in elite players, and that their ability to sustain this intensity further decreased as matches progressed. There also appeared to be a relationship between body composition and ability to sustain exercise intensity, with those referees displaying higher levels of body fatness demonstrating a greater reduction in exercise intensity between the first and final quarters. This

inability to maintain exercise intensity may negatively influence the ability to make good decisions in the latter stages of matches.

Although it may be possible that maintenance of high levels of intensity may not be 'optimal' from a referees perspective and that the observed reduction in exercise intensity in the latter stages of matches could be indicative of a strategy used to optimise performance, the finding that the degree of reduction in intensity is greater in the 'high fat' than the 'low fat' group would suggest that it is more likely to be indicative of levels of physical conditioning. Further research is required in order to better understand the conditioning requirements of elite level refereeing, and also the quality of referees' decision making over the entire duration of elite level game-play.

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