TITLE:	The effect of match standard and referee experience upon the objective and subjective match workload of English Premier League referees

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Abstract

The aim of the present study was to examine the effect of match standard and referee experience upon the objective and subjective workload of referees during Premier and Football league soccer matches. We also examined the relationship between heart rate (HR) and ratings of perceived exertion (RPE) for assessing match intensity in soccer referees. Heart rate responses were recorded using short-range telemetry and RPE scores were collected using a 10-point scale. Analysis revealed a significant relationship between mean match HR and match RPE scores ($r = 0.485$, p < 0.05, $n = 18$). There were significant differences in match HR (Premier league 83.6 ± 2.6 %HR$_{max}$ vs. Football league 81.5 ± 2.2 %HR$_{max}$, p < 0.05) and match RPE scores (Premier league 7.8 ± 0.8 vs. Football league 6.9 ± 0.8, p < 0.05) between standards of competition. Referee experience had no effect upon match heart rate and RPE responses to Premier and Football league matches. The results of the present study demonstrate the validity of using HR and RPE as a measure of global match intensity in soccer referees. Referee experience had no effect upon the referees' objective and subjective match workload assessments, whereas match intensity was correlated to competition standard. These findings have implications for fitness preparation and evaluation in soccer referees. When progressing to a higher level of competition, referees should ensure that appropriate levels of fitness are developed in order to enable them to cope with an increase in physical match demands.

Keywords: soccer, refereeing, heart rates, ratings of perceived exertion, competition

Introduction

Due to the practicality of monitoring referees' heart rates during the course of a soccer match, as they do not experience physical contact [1], heart rate (HR) responses during competitive matches have already been reported within the literature [2,3,4]. Krustrup and Bangsbo [4] reported that over the duration of selected Danish league matches, the referees' HR was calculated to be $85 \pm 1\%$ of maximal HR (HR_{max}). This figure was consistent with the $85 \pm 5\% HR_{max}$ reported for top-class referees during the 2000 European Soccer Championships [3]. However, Krustrup and Bangsbo [4] reported that HR recordings obtained on referees during a match may overestimate the physical intensity of matches because such factors as isometric contractions, thermal and emotional stress can elevate HR beyond the normal $HR-VO_2$ relationship. Indeed, Jeukendrup and van Diemen [5] reported that HR recordings during competitive exercise might be a better indicator of whole body metabolic stress as opposed to exercise intensity.

Ratings of perceived exertion (RPE) have been widely used to assess exercise intensity and when the scale is used correctly it is a very accurate method for monitoring exercise intensity [6]. Furthermore, Foster [7] reported that the RPE technique is consistent with objective physiological indices of exercise training. However, the relationship between subjective data obtained using this technique and objective data, acquired using HR recordings, has yet to be examined with regards to the assessment of global match intensity in elite soccer referees.

Authors have reported that soccer match intensity is correlated with the level of competition [8,9]. Mohr et al. [9] reported that top-class players performed more high intensity running during matches, a valid measure of physical match performance in soccer, than moderate professional players did. This difference in intensity with match standard may impact upon referees' objective and subjective match workload responses when refereeing at different levels of competition. However, the effect of competition standard upon match intensity in elite soccer referees has yet to be thoroughly examined. Catterall et al. [2] using data collected from Premier, Football and non-Football league matches, reported that the mean HR was unaffected by the category of competition, although higher peak HR's were recorded during games in the top division. Unfortunately, HR data were only collected from one match per referee. Therefore, as the referees did not officiate at more than one standard of competition, an accurate assessment of the effect of match standard upon match intensity remains relatively unexplored.

Wilkins et al. [10] observed high HR's during periods of low physiological stress when psychological stress was likely to be high, such as restraining players and intently watching play. As mental stress can elevate HR through the release of such hormones as adrenaline and noradrenaline [11], referee experience may also have an impact upon the HR responses during matches as psychological stress may be reduced as officials gain more experience [10]. Krustrup and Bangsbo [4] reported few significant differences in observed match activities between top-class (international) and high standard (national) Danish referees. However, the referees' HR's were measured on

only two occasions. To our knowledge, no attempt has been made within the literature to examine the effect of experience upon referees' match HR's and also RPE scores.

Therefore, the objectives of the present study were to: i) examine the relationship between HR and RPE during soccer matches; and, ii) investigate the effect of match standard and referee experience upon referees' subjective and objective ratings of global match intensity.

Method

Participants

In English soccer, the highest level of competition is the FA Premier league. The Football league is the next level down and is comprised of three separate divisions with a progressive decrease in standard from the first to the third division. Data were collected from 18 out of the 20 full time, professional English Football Association (FA) Premier league referees who were comfortable wearing a HR monitor during their matches. The match HR and RPE data were collected as part of the on-going sports science support provided to the Premier league referees by the first author of this study, whereby objective and subjective ratings of exercise intensity are used to evaluate the referees overall training and match loads. The mean age and experience, in terms of years refereed on the Premier league, was 41.8 years (range 33 to 47 years) and 5.4 years (range 2 to 11), respectively.

Assessment of RPE

Each referee was asked to assess and record the RPE following each of their matches during the 2002-2003 English football season, giving a total of 527 match observations (median of 31 matches, range 6 to 41). The referees recorded their RPE score 30 minutes after the match had ended in order to obtain a global intensity rating for the entire match. Therefore, a particularly easy or difficult bout of exercise towards the end of the match would not dominate the referees' rating, as per Foster [7] and Foster et al. [12]. The scale used in the present study was the category ratio scale (CR10-scale) from Borg et al. [6] and has been reported to correlate significantly with objective indices of exercise training such as HR and blood lactate [12]. The referees were familiarised with the use of RPE scores as they had used the scale as part of their training monitoring procedures over a 12 month period prior to the study.

Heart rate sampling

The referees' HR during matches was recorded via short-range telemetry using Polar S610 watches (Polar, Kempele, Finland), with the data being recorded every 5 seconds. The referees were already familiarised with how to use the HR monitor and its functions, and were also aware of how to correctly fit the transmitter. The referees were instructed to insert markers into the HR files, using the appropriate button on the HR monitor, in order to indicate the precise moment at which the match halves started and ended. Data recording commenced from the start of the referees' warm up and finished upon the final whistle. Following each match, the data were downloaded onto a computer for analysis using the Polar Precision software, version 3.0 (Polar, Kempele,

Finland). Figure 1 provides a typical example of a referee's heart rate response to a Premier league match.

Insert Figure 1 about here

Study design

The referees in the present study officiate on the FA Premier League, with few selected matches during the season on the Football League. Due to the limited number of matches refereed at the lower standard of competition, HR recordings and RPE scores from a total of 6 matches per referee were analysed during the 2002-2003 soccer season and these matches consisted of 3 Premier and 3 Football league matches in an attempt to examine the effect of match standard upon the referees' HR and RPE responses during matches. The 6 matches were grouped into 3 pairs, with data collected from each Football league match taking place within 14 days of data collected from a Premier league match in an attempt to eliminate any potential impact of fitness variations upon the referees' match data. To gain an accurate representation of the whole season, and to eliminate any possible effect of seasonal variation on heart rates, as thermal stress can elevate HR beyond the normal HR-VO_2 relationship [4], the season was divided into three equal segments: August – October, November – January and February – April. Each pair of match observations was taken from each segment of the season. Also, the HR responses of eight randomly chosen referees during 4 matches, 2 Premier and 2 Football league, were studied in order to determine the intra-referee variation.

The referees' experience of refereeing on the Premier League was recorded at the beginning of the 2002-2003 football season. To examine the effect of referee experience upon match HR and RPE responses during Premier and Football league matches, the referees were divided into two groups; a low experience group, with 4 seasons or less refereeing on the Premier league ($n = 10$, 3.1 ± 0.9 years experience) and a high experience group with more than 4 seasons refereeing on the Premier league ($n = 8$, 8.4 ± 2.2 years experience).

Laboratory assessment for maximal heart rate

All of the 18 referees who participated within this study visited the laboratory in September 2002 and completed a maximal, incremental test for the determination of HR_{max} and VO_{2max}, as part of the on-going sports science support provided to the referees. Following 5 minutes of self-paced warm up running, the referees performed an interval-based protocol, which compromised of five 4 minute stages, on a motorised treadmill (Woodway, Germany). These stages were interspersed with a 30 second recovery period during which the referees stopped running, straddled the treadmill belt and the test administrator increased the running speed. The initial running speeds were selected from the perceived fitness of the referees with each referee starting the protocol at either 6.5 or 7.1 miles.hr^{-1}, with a treadmill inclination of 1%. The speed was then subsequently increased by 0.6 miles.hr^{-1} for each of the following 4 stages. At the end of the fifth stage the referees continued to run and the inclination on the treadmill was

increased by 1% every 30 seconds until volitional exhaustion. Heart rate was monitored via short-range telemetry using Polar S610 watches (Polar, Kempele, Finland) and the referees' HR_{max} was calculated as the highest 5 seconds peak value attained during the assessment.

Statistical Analysis

The following dependent measures were identified and calculated:

- The mean match HR was obtained from the recordings during the entire match, including periods of time added on for stoppages at the end of each half. The value was expressed both absolute and relative to the referees' HR_{max}.

- Within match HR: matches were divided up into 6 periods over the duration of the match in accordance with previous studies [1,3] with the mean absolute and relative HR's being recorded for each of these periods. These periods were from the kick off to 15 minutes, 16 minutes to 30 minutes and 31 minutes until the end of each 45 minute half. This procedure enabled the detection of whether or not the referees modified their activity pattern during the game [1].

Pearson's product moment correlations were calculated on the relationship between RPE and the mean match HR for each individual referee. A z-statistic was used to test for signifcance of the correlation coefficient. The coefficient of variation was used as a measure of intra-referee match HR responses [13].

A Students paired *t*-test was used for the analysis of the Premier league referees' mean match HR's, peak match HR and match RPE scores on both Premier and Football

league matches; a repeated measures design over two occasions. To further examine the effects of match standard on match HR responses throughout the 6 15-minute periods, a two-way ANOVA was carried out on the heart rate, expressed as $\%HR_{max}$ values, using a 2 Match standard (Premier league, Football league) by 6 Period (Periods 1 - 6) design with repeated measures. When a significant interaction was detected, the data were subsequently analysed using a Tukey-Kramer *post hoc* test. Differences between high experience and low experience referees' mean match heart rates and match RPE scores were determined by an unpaired *t*-tests. Significance was set at $p < 0.05$.

Results

Relationship between RPE and mean match heart rate

Figure 2 illustrates the relationship between mean match HR's and mean match RPE scores for each referee (*n*=18). There was a significant correlation between mean match HR and mean match RPE score ($r = 0.485$, $p < 0.05$, $n = 18$).

Insert Figure 2 about here

Match Standard

The mean match HR reponse for the Premier league referees was higher when refereeing Premier league matches when compared to Football league matches ($83.6 \pm 2.6\%HR_{max}$ vs. $81.5 \pm 2.2\%HR_{max}$, $p = 0.0027$). However, there were no differences in the Premier league referees peak heart rates on Premier and Football league matches ($95.6 \pm 2.5\%HR_{max}$ vs. $95.0 \pm 2.1\%HR_{max}$, $p > 0.05$). The mean match RPE scores for the Premier league referees were also significantly higher for Premier league matches compared to Football league matches (7.8 ± 0.8 vs. 6.9 ± 0.8, $p < 0.0001$).

Insert Figure 3 about here

As can be seen from Figure 3 the results of the 2 (Match Standard) X 6 (Match Period) ANOVA showed a significant effect for Match Standard ($F_{1,34} = 6.22$, $p = 0.017$), with the within match heart rates on Premier league being higher throughout the entire match when compared to the Football league matches. There was also a significant effect for Match Period on the within match HR's ($F_{5,85} = 18.90$, $p < 0.001$). Results of the *post hoc* analysis showed that during both Premier and Football league matches HR's in the second half of matches increased from period 4 to period 6 but not for the corresponding periods during in the first half (periods 1 to 3). The lowest match period HR for both standards of competition was period 4, which was the first 15 minutes of the second half. The pattern of the HR response over the six match periods was unaffected by the standard of competition ($F_{5,170} = 0.23$, $p = 0.948$) in that the within match heart rates displayed an almost parallel trend over the duration of the Premier and Football league matches.

Referee Experience

Mean HR's for both low experience (82.7 ± 8.6%HR_{max} vs. 80.8 ± 5.6%HR_{max}, p < 0.001) and high experience referees (84.8 ± 2.4%HR_{max} vs. 82.3 ± 2.3%HR_{max}, p = 0.016) were higher during Premier league matches compared to Football league matches. However, both Premier league (p = 0.084) and Football league (p = 0.134) mean match HR's were unaffected by referee experience. Referee experience had no effect upon match RPE scores during both Premier (7.8 ± 0.5 vs. 7.7 ± 1.0, p = 0.872) and Football league matches (6.8 ± 0.7 vs. 6.9 ± 0.9, p = 0.755).

Intra-referee variation

The HR responses of eight referees during 4 matches, 2 Premier and 2 Football league, were studied in order to determine the intra-referee variation. For the Premier league matches the mean intra-referee variation was calculated to be 2.5 beats.min^{-1} (0.4 – 5.8 beats.min^{-1}), with a coefficient of variation of 1.7%. For the Football league matches, the mean intra-referee variation was observed to be 2.4 beats.min^{-1} (0.4 – 6.0 beats.min^{-1}), with a coefficient of variation of 1.7%.

Discussion

In this study we assessed the validity of using heart rates as an indicator of global match intensity in soccer referees by examining the relationship between match HR's and match RPE scores. Ratings of perceived exertion has been reported to be a valid, subjective estimate of physical load during non-steady state exercise, including very high-intensity interval training and team sport practice and competition [7,12]. In the present study mean match HR's were significantly correlated with RPE scores. Therefore, despite HR's being previously reported to overestimate slightly the physical load placed upon referees during matches [4], our results demonstrate that match HR's may be considered as a valid indicator of global match intensity in this group of elite-level soccer referees. Also, a low coefficient of variation in match HR's suggests that HR's can be regarded as a valuable parameter to evaluate intra-referee match intensity. Due to the practicality and cost effectiveness of such intensity assessment techniques they can be used by referees at all levels of the game in order to assess the subjective and objective workload imposed upon them during matches.

The fact that the referees' HR increased significantly from the first to the last period of the second half for both standards of competition may be attributed to cardiovascular drift. Krustrup and Bangsbo [4] reported that dehydration accounted for a 5 beats.min^{-1} rise in referee HR over the duration of a half. Also, Reilly [14] reported that the distribution of goals shows a bias towards more goals being scored at the end of the game. This final burst of activity by the players may have, in turn, led to an increase in activity by the referees which would be manifested through an increased HR.

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During both Premier and Football league matches, the first fifteen minute period of the second half produced the lowest HR recordings. Literature has demonstrated that for both soccer players [9,15] and referees [1,4] match intensity is lower during the second half of matches, especially during the initial stages of the second half. Also, Krustrup et al. [16] reported that the quadriceps muscle temperature of match officials was lowered by more than $1^{o}C$ following the half time interval and this was concomitant with a reduced physical performance during the initial period of the second half.

Premier and Football league match HR's and RPE scores were not related to refereeing experience. However, match heart rates and RPE scores recorded from the referees were significantly higher during Premier league matches compared to the Football league. As match heart rates have been significantly correlated with subjective ratings of exercise intensity, it appears that for this group of elite-level referees' global match intensity is correlated to the standard of competition refereed as both subjective and objective measures of physical workload were significantly higher during the higher standard of competition. This finding is consistent with the research on players, which has demonstrated that soccer match intensity is correlated with the level of competition, with higher standard matches being more intensive [8,9].

As global match intensity was correlated to the level of competition this clearly has an implication upon a referee's fitness preparation and evaluation. Referees and football governing bodies should ensure that appropriate levels of match fitness are developed in

order to enable referees to cope with the increase in match intensity that accompanies an elevation in competition standard.

The measurement, and subsequent analysis of HR and RPE can provide referees and training experts with useful implications for training monitoring, thus ensuring referees can cope with the physical demands of their matches at all levels of competition. Heart rates have been used to detect overtraining at an early phase, either at rest, during a maximal assessment and also during sleep [5]. Session RPE scores, defined as session duration multiplied by the RPE score, enable accessory indices of training to be calculated, such as monotony and strain [7]. Therefore, the combination of HR and RPE monitoring during training and competition may allow a referee to achieve the goals of training while minimising undesired training outcomes.

In conclusion, the relationship between match heart rates and RPE indicates that HR's may be considered as a valid measure of referees' workload during competitive matches. Experience had no effect upon the referees' objective and subjective match workload assessment. However, the referees' global match intensity recordings were correlated to the level of competition as the referees recorded higher HR's and RPE scores for the higher standard of competition. This has clear implications upon the fitness preparation and evaluation of referees when progressing to a higher standard of competition.

Practical Implications

♦ The results of the present study demonstrate, through increased HR's and RPE scores, that match intensity in Premier league referees is correlated with the level of competition, with higher standard matches being more intensive.

♦ These results have implications for a referee's fitness preparation and evaluation, in that referees and football governing bodies should ensure that appropriate levels of match fitness are developed in order to enable referees to cope with the increase in match intensity that accompanies an elevation in competition standard.

♦ Despite an increase in global match intensity at the higher standard of competition, objective and subjective ratings of exercise intensity during matches were unaffected by referee experience.

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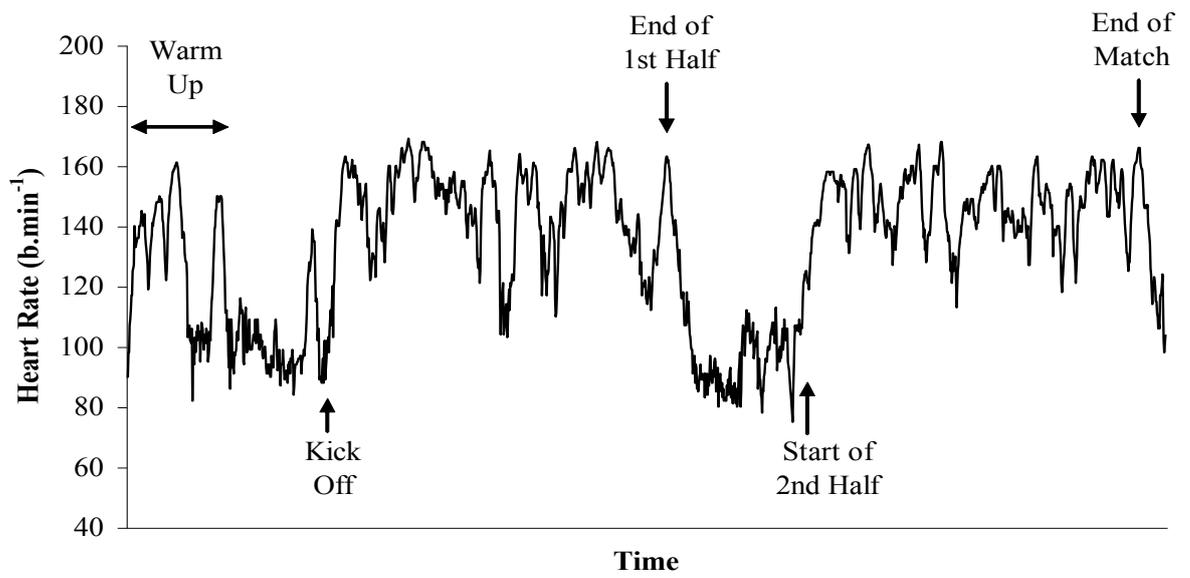
Figure 1 An illustration of a referee's HR response to a typical Premier league match
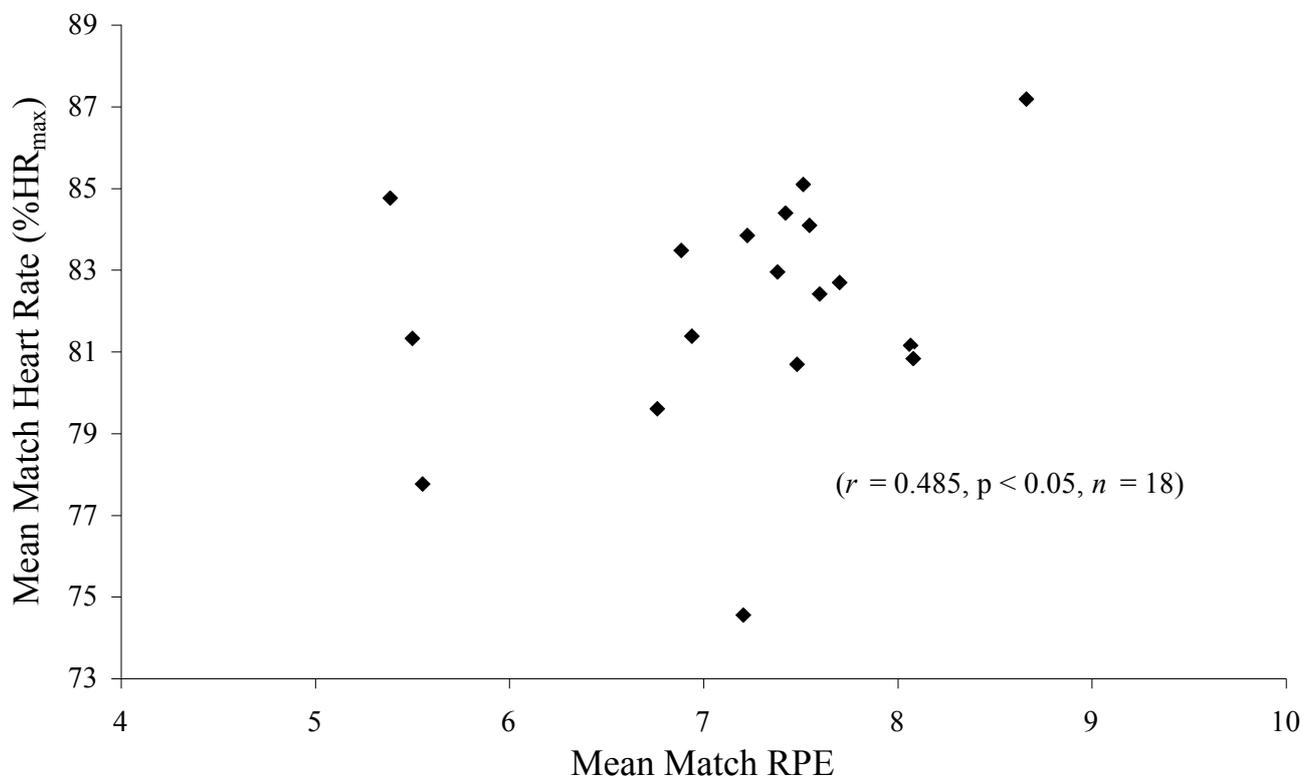
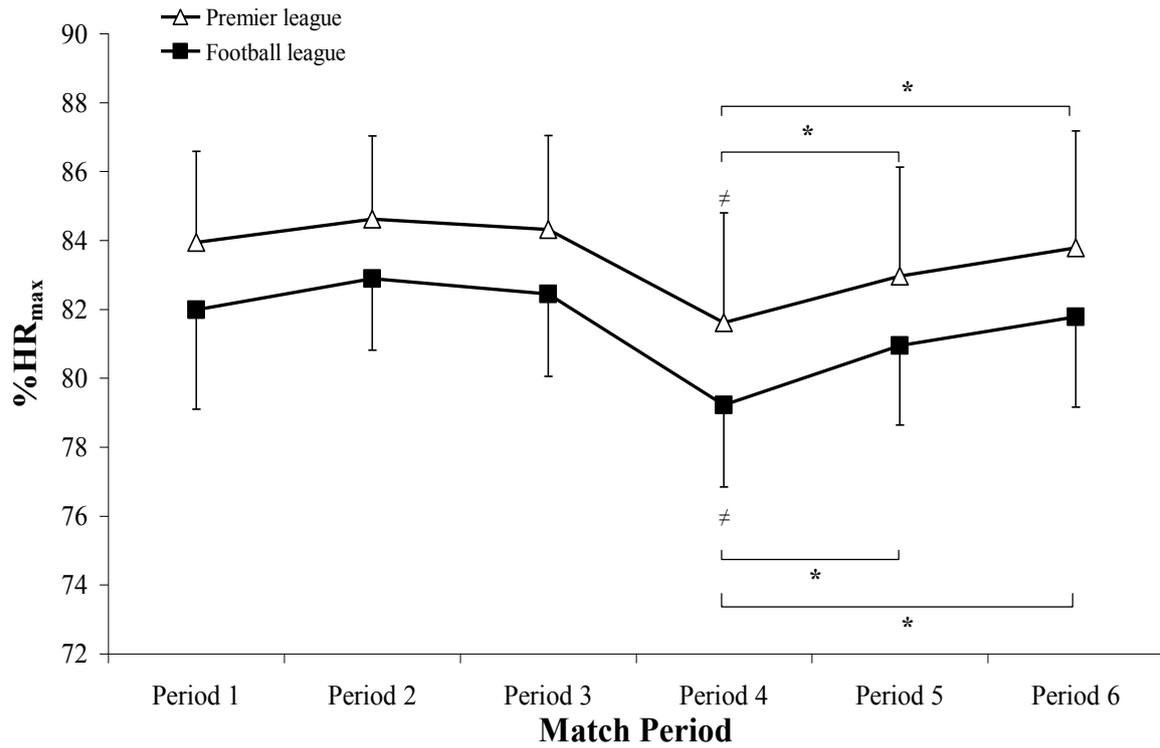Figure 2 The relationship between mean match HR's and match RPE scores

Figure 3 Referees' mean ($\pm$ sd) within match HR responses per match period during three Premier and Football league matches; * $p < 0.001$; $\neq$ statistically different from all other match periods at each standard of competition ($p < 0.05$).