a) Ageing and Physical Match Performance in English Premier League Soccer Referees

b) Running title: Age and match activity in referees

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ABSTRACT

Soccer referees are required to keep up with play at all times despite occupying an age bracket on average 10 to 15 years older than their playing counterparts. Therefore, the aim of the present study was to examine the effect of age upon the physical match performances and match physiological loads of elite-level soccer referees. Match analysis data was collected (Prozone® Leeds, UK) from 22 professional soccer referees (age range 31-48 years) on FA Premier League matches over four consecutive seasons (778 observations). Physical match performance categories were: total-distance covered (TD); high intensity running distance (speed >5.5 $m \cdot s^{-1}$, HIR); sprint count (>7.0 $m \cdot s^{-1}$, SC); top sprinting speed (TS); average distance from the ball (DB) and average distance from fouls (DF). Significant age-effects were found for TD (r=-0.52, $p<0.001$), HIR (r=-0.53, $p<0.001$) and SC (r=-0.53, $p<0.001$). No age-effect was found for DB and DF ($p>0.05$). Despite covering less TD, HIR and performing fewer sprints the older referees (43-48 years) were able to maintain an average distance from fouls that was comparable to that recorded by the young (31-36 years) referees. Therefore, the reduced physical match performances associated with increasing referee age did not appear to impact upon the older referees' ability to keep up with play. In light of these findings, refereeing governing bodies may wish to review their age-based retirement guidelines.

Key words: Football; match analysis; positioning; work-rate; experience

INTRODUCTION

The match activity profiles and physiological demands of soccer referees during competitive matches have been reported to be very similar [1-3] and also related to those of the players [4]. Consequently, the referee is required to keep up with play at all times despite occupying an age bracket on average 10 to 15 years older than their playing counterparts. The difference between the average age of players and referees may exist because experience is considered as a fundamental prerequisite to officiate at elite level [5]. International refereeing governing bodies have an enforced retirement age of 45 years for referees. However, in some countries this enforced retirement has been successfully challenged as it is considered to be against the European Employment Directive, which prohibits age discrimination in employment.

The scientific rationale behind an enforced retirement age limit for referees is not clear. One of the reasons may be the well documented age-related decline in physical fitness [6-8] given the importance placed on a referees fitness levels [5,9]. Any decline in fitness may impair a referee's ability to keep up with the play, yet in order to apply the laws of the game accurately a close proximity to fouls is considered important for a fair judgement [1,3,10].

However, whilst significant age-related impairments in physical fitness have been reported in soccer referees [11,12] the relationship between age and physical match performance has yet to be examined. Therefore, the aims of the present study were to 1) examine the effect of age upon the physical match performances of soccer referees in relation to the distance from fouls and the ball over the course of four consecutive seasons; and 2) examine the effect of age upon the physiological load imposed upon soccer referees during competitive matches.

METHODS

Data were collected from 22 professional English Football Association (FA) Premier League referees on FA Premier League matches over the duration of four seasons; 2003-2004, 2004-2005, 2005-2006 and 2006-2007, giving a total of 778 match observations. The referees' age was taken on the first day of each season. In line with previous studies [11,12] the referees were assigned to three different age-group categories; young (31-36 years, *n*=135 match observations), intermediate (37-42 years, *n*=308 match observations) and older (43-48 years, *n*=335 match observations). However, as the retirement age on the English Premier league is 48 years as opposed to 45 years on the Italian and Spanish top leagues, the average age of the groups in the present study were higher than those previously reported [11,12]. Written informed consent was received from all referees after verbal and written explanation of the experimental design and potential risks of the study. The local Institutional Review Board approved this study design.

In order to examine the effect of ageing upon the referees physical match performances and physiological stress the match activity, ratings of perceived exertion (RPE) and heart rate (HR) data from each of the referee's matches during each season were averaged to give a mean score for that particular year of age. Consequently the referees represented a total of 69 different age years (range 31-48 years) across the four soccer seasons considered. Therefore an average value for each of the variables of interest for each age year was obtained. However, due to retirement and also promotion, not all the referees involved contributed data on each of the four seasons (3.2±1.1 seasons per referee). To further examine the possibility of age associated variations the match activity, RPE and HR data were assigned to the three referee age-group categories.

Each match was monitored using a computerised, semi-automatic video match analysis image recognition system (ProZone®, Leeds, England). The system has showed an almost perfect

correlation with a timing gate measurement system at velocities ranging from 7.5 km.h^{-1} to 25 km.h^{-1} for 60m runs (r=0.99), 50m angled runs (r=0.99) and 20m maximal sprints with a change of direction (r=0.95) [13]. The objective measures of match running performance selected for analysis were: 1) total distance covered (TD); 2) high intensity running distance (running speed >5.5 m·s^{-1} (>19.8 km·h^{-1}), HIR); 3) sprint count (running speed >7.0 m·s^{-1} (>25.2 km·h^{-1}), SC; 4) top sprinting speed (m·s^{-1}, TS); 5) mean distance from the ball (m, DB); 6) mean distance from fouls (m, DF). Also, as the physical match performances of English Premier league soccer referees have been demonstrated to be in part related to players' HIR [4] the sum total of the players HIR distance (running speed >5.5 m·s^{-1} (>19.8 km·h^{-1}), PHIR) during each match was also recorded as a measure of overall match intensity.

The referees recorded their RPE score, using Borg's CR10 scale [14], 30 minutes after the match had ended to obtain a global intensity rating for the entire match [15,16]. Therefore, a particularly easy or difficult bout of exercise towards the end of the match would not dominate the referees' rating. This scale has been reported to correlate significantly with objective indices of exercise training such as HR and blood lactate [16]. The referees were familiarised with the use of RPE scoring having used it over a 12-month period prior to the study. Match HR was recorded every 5 seconds and analysed via a short-range telemetry system (Polar S610 and Precision 3.0 Kemple, Finland, respectively).

Match RPE load was determined by multiplying the match duration (minutes) by the session RPE score [15]. This method allows physiologists to quantify internal training load into a single term that balances exercise duration and intensity [17]. Recent studies have demonstrated that the RPE load method is a valid tool for quantifying training load in team sports including soccer [15,18].

Match HR load was computed by multiplying the accumulated duration in each of five different HR zones by a multiplier for each zone (<60%HR_{max} = 1; 60-75% = 2; 76-85% = 3; 86-93% = 4; >93% = 5) and summating the results [19]. The HR zones in this study were based on the individual physiological response to incremental exercise as described by Bourdon [20]. The referees' individual HR_{max} values were determined from the peak values reached in any of the 5 second periods observed during matches, training sessions or fitness tests [3,21].

Data are presented as the mean ± standard deviation. The Shapiro-Wilk test was applied to the data in order to assess for a normal distribution of parametric data. Relationships between the referees' age and their physical match performances and physiological match responses were examined using a Pearson's product moment correlation. The following scale of magnitudes proposed by Hopkins [22] was used to interpret the correlation coefficients: <0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; >0.9, nearly perfect. Levene test for Equity of Variances was computed with no significant differences being found. A one-way analysis of variance (ANOVA) was used to determine differences in physical match performance between the groups of referees. Analysis of covariance (ANCOVA) was performed assuming PHIR as covariate [4]. Post-hoc analyses were performed using Tukey's Unequal-N HSD test. Effect sizes (η^2) were also calculated and values of 0.01, 0.06 and above 0.15 were considered small, medium and large, respectively. Statistical significance was set at $p<0.05$. All calculations were performed using the Statistica statistical analysis software package (Version 6.0).

RESULTS

Figures 1 illustrates large negative correlations between referee age and the match variables of TD (r =-0.52 [CI 95%:-0.67;-0.32], $p<0.001$, n=69), HIR (r =-0.53 [CI 95%:-0.68;-0.33], $p<0.001$, n=69) and SC (r =-0.53 [CI 95%:-0.68;-0.33], $p<0.001$, n=69). TS showed a small

correlation with age (r=-0.26 [CI 95%:-0.47;-0.02], p=0.034, n=69). The match variables of DB and DF showed no relationship with age (p>0.05) nor did the referees' match HR load (p>0.05). Whereas, match RPE showed a moderate correlation with referee age (r=0.35 [CI 95%:0.12;0.54], p<0.01, n=69).

As can be seen from Table 1, ANOVA results demonstrated a significant age effect upon selected referee's physical match performance variables. Specifically, when split into three different age-group categories the young referees covered a greater TD when compared to the intermediate and older referees (p<0.05), with HIR and SC both decreasing with increasing referee age group (p<0.05). In terms of TS the older referees were significantly slower when compared to the young and intermediate groups (p<0.01). No significant differences were found between the young and older group for DB and DF (p>0.05).

With regards to overall match intensity there were no differences between the PHIR in the matches officiated by the three age groups (p>0.05). Also, there were no between group differences for match HR load ($F_{2, 709}$=0.22, p=0.802). Conversely, the referees match RPE load was significantly higher in the older group when compared to the young and intermediate (p<0.0001) age groups. Effect size for all comparisons was small (η^2<0.02). ANCOVA results were not different from one-way ANOVA analysis.

DISCUSSION

The results of the present study demonstrated an age-related decline in elite-level soccer referees physical match performances as TD, HIR and SC all decreased as referee age increased. Furthermore, the differences between young and older groups were greater for HIR and SC when compared to TD (-28.4, -35% vs. -7.4%, respectively). This decline in physical match

performance may be related to the age associated impairments in physical capacities already reported in soccer referees [11,12]. Specifically, Casajus and Castagna [11] and Castagna et al. [12] both reported a greater age-related decrement in anaerobic performance when compared to aerobic capacity. Our findings seem to be consistent with these results since the age-related decline in physical match performance was more pronounced amongst the predominantly anaerobic match variables of HIR and SC. Unfortunately, a limitation of the present study was that it was not possible to report on the referees' fitness levels as determined through regular fitness tests. Therefore, the link between the decline in physical fitness and physical match performance cannot be examined. However, irrespective of the reasons, the present study showed a moderate but significant age-related decline in generic physical match performance.

No correlations were observed between age and the referees' DB and DF. A 2-3% lower DB and DF was found for older referees compared to intermediate but not younger referees. However, a difference of 0.4m is of limited practical significance (small effect size: $\eta^2<0.02$) and may have been influenced by the large sample size of the study. Referees are required to keep up with play at all times and ensure optimal viewing positions [23]. In the present study the older referees reduced physical match performances did not affect their ability to keep up with play. As a result, it maybe the effectiveness of the referees match activities in ensuring the best possible viewing positions that is of most relevance. Expertise literature has demonstrated that experts are better than novices in using advance visual cues to guide their anticipatory responses [24,25]. Therefore, our findings may be explained by the older, more experienced referees being better at anticipating and reading play and ultimately being more economical with their movements due to their many years of practice.

The relationship between DB and DF with viewing angle and ultimately correct decision making has yet to be examined and was beyond the scope of the present study. It maybe that the DF

could be consistent between referees, yet the referees are viewing incidents from two entirely different angles, i.e., head-on and side-on. Consequently, this is an area that warrants further investigation given that no differences in DF were found despite wide ranging physical match performances.

The referees match HR load showed no relationship with age. Conversely, match RPE load demonstrated a moderate correlation with referee age (r=0.35, p<0.01, n=69) and the older referees match RPE load was significantly higher when compared to the young and intermediate age groups despite covering less TD, HIR and performing fewer sprints. This may in part be explained by the fact that the experienced referees are more often assigned to officiate high profile matches, which may have led to an increase in the perceived match intensity, although no between-group differences were observed for PHIR. Alternatively, given the older referees in the present study perceived their match demands to be higher, despite covering less ground and at the same HR, the higher RPE might suggest greater fatigue.

The present studies findings would appear to suggest that the enforced retirement age of 45 years may not be justified by the inability of the referees to keep up with the play as the average age of the older group in this study was 44.8 years. Or, it may be that this enforced retirement age of 45 years has become dated with the increased fitness levels observed in referees over recent years after following more modern training regimes [3,23] and also the advent of full-time, professional soccer referees.

CONCLUSION

The current findings demonstrated that reduced physical match performances with increasing referee age did not impact upon the older referees' ability to keep up with play. Such findings have a great deal of practical significance in a sport where the international governing body has an enforced retirement age of 45 years. It may be that the referees technical performances, fitness

levels and physical match performances are all factors that should be taken into consideration when it comes to the assessment of whether a referee is 'fit for purpose'. Since the referees of the present study possibly experienced greater fatigue as indicated by the higher RPE load, future studies should examine if fatigue has an impact upon a referees decision making process. Therefore, it is recommended that physical performances should be related to the decision making process in an attempt to fully determine the impact of ageing upon match performance in soccer referees. Lastly, future studies should examine the relevance of distance from fouls in relation to viewing positions and ultimately correct decision making in soccer referees.

PRACTICAL IMPLICATIONS

- Referees' physical match performances reduce with increasing age;
- Age does not appear to impact upon older referees' ability to keep up with play;
- Referees retirement should be undertaken considering ability to officiate and physical capacity;

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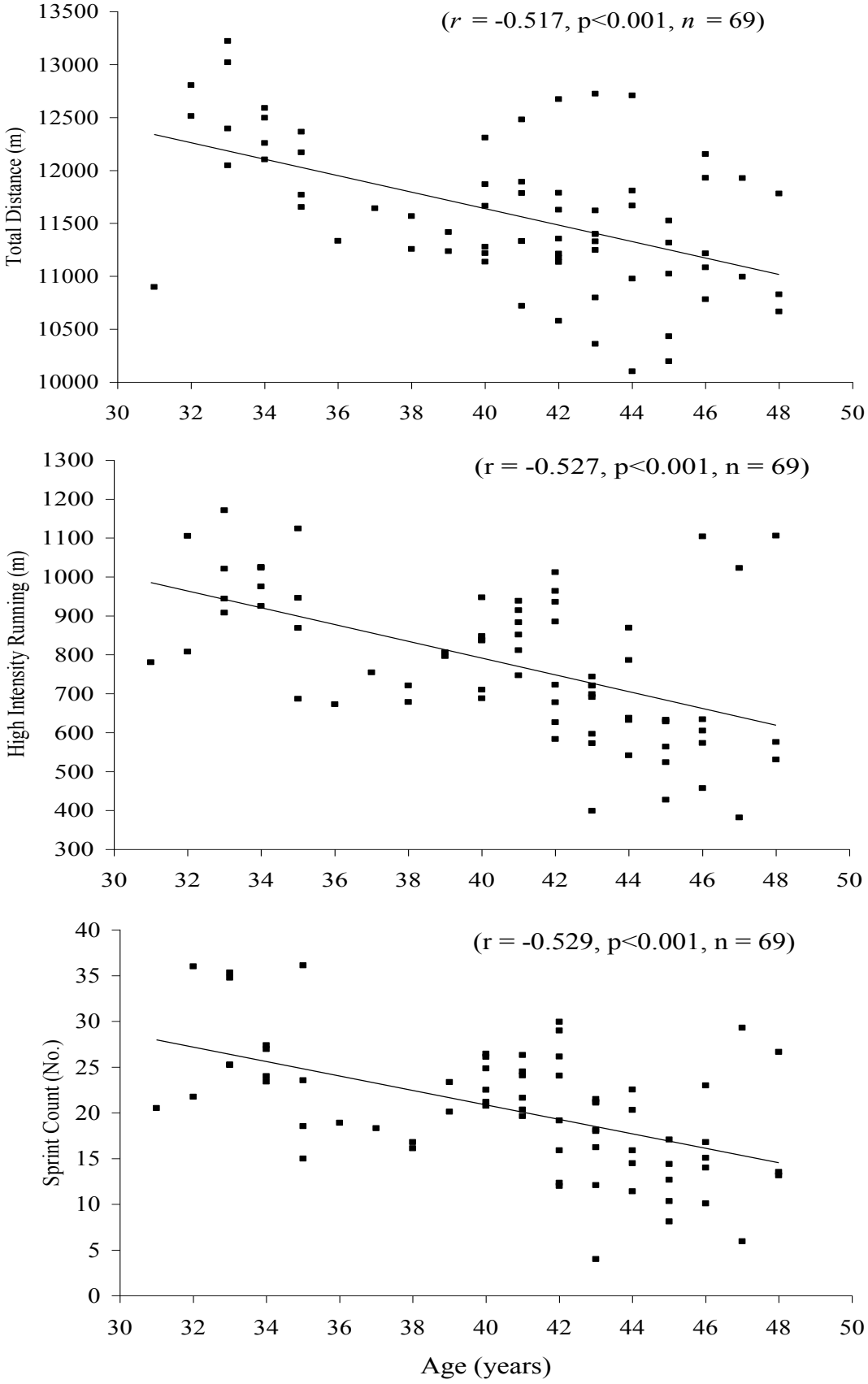

Figure 1 Scatterplots of the significant correlations between referee age and physical match performance variables

Table 1 Referees' match activity and physiological load during Premier League matches

	All	Young *n* = 6 (31-36 years)	Intermediate *n* = 8 (37-42 years)	Older *n* = 8 (43-48 years)
Match Observations	*n* = 778	*n* = 135	*n* = 308	*n* = 335
Total Distance (m)	11534 ± 748	12209 ± 713 $^{\neq}$ §	11490 ± 570*	11302 ± 749
High Intensity Running (m)	773.1± 253.6	935.9 ± 250.7 $^{\neq}$ §	814.8 ± 203.4 *	669.2 ± 251.6
Sprint Count (no.)	20.1 ± 11.5	25.4 ± 12.6 $^{\neq}$ §	21.7 ± 10.6 *	16.5 ± 10.6
Top Speed ($m.s^{-1}$)	8.60 ± 0.52	8.69 ± 0.43 §	8.64 ± 0.50 *	8.53 ± 0.56
Players High Intensity Running (km)	19.5 ± 2.2	19.1 ± 2.3	19.6 ± 2.0	19.6 ± 2.4
Distance from Ball (m)	19.3 ± 1.1	19.0 ± 1.2 $^{\neq}$	19.5 ± 0.9 *	19.1 ± 1.2
Distance from Fouls (m)	14.4 ± 1.6	13.9 ± 1.5 $^{\neq}$	14.7 ± 1.6 *	14.3 ± 1.5
Match Load				
RPE Load (au)	645.6 ± 140.0	599.2 ± 132.3 §	623.1 ± 150.0 *	685.6 ± 122.7
HR Load (au)	313.5 ± 35.2	314.8 ± 30.6	313.8 ± 42.7	312.5 ± 27.5

$^{\neq}$ Significant difference between young and intermediate groups ($p<0.05$). § Significant difference between young and older groups ($p<0.05$). * Significant difference between intermediate and older groups ($p<0.05$).