

Intensities of exercise during matchplay in FA Premier League referees and players

Running title: Referee and player running speed patterns

Matthew Weston^{1,2}, Barry Drust³ & Warren Gregson³.

¹Department of Sport & Exercise Sciences, School of Social Sciences & Law, Teesside University, Middlesbrough, UK; ²The Professional Game Match Officials Limited (PGMOL), The FA Premier League, 30 Gloucester Place, London, UK; ³Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, United Kingdom.

Corresponding Author:

Dr Matthew Weston

Department of Sport & Exercise Sciences

School of Social Sciences & Law

Teesside University

Middlesbrough

UNITED KINGDOM

e – m.weston@tees.ac.uk

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ABSTRACT

The aim of the present study was to examine the relationship between intensities of exercise during matchplay of elite-standard soccer referees with those of the players from the same match. Match analysis data were collected (Prozone® Leeds, UK) from 18 elite-standard soccer referees (age range 26-49 years) on FA Premier League matches during the 2008/09 English FA Premier League season (236 observations). Match-running categories for referees and players were: total distance covered; high-speed running distance (speed > 19.8 km.h⁻¹); and sprinting distance (> 25.2 km.h⁻¹). Analysis of the distance-time regression coefficients revealed no differences between the referees' and players' within-match rates of change for total distance covered (-0.594 ± 0.394 vs. -0.713 ± 0.269 m.min⁻¹, p=0.104), high-speed running (-0.039 ± 0.077 vs. -0.059 ± 0.030 m.min⁻¹, p=0.199) and sprinting (-0.003 ± 0.039 vs. -0.021 ± 0.017 m.min⁻¹, p=0.114). Also, there were no differences between across-season rates of change for total distance (-26.756 ± 40.434 vs. -20.031 ± 25.502 m.match day, p=0.439) and sprinting (-9.662 ± 7.564 vs. -8.589 ± 4.351 m.match day, p=0.542). These results show that elite-standard soccer referees' intensities of exercise during matchplay are interrelated with those of the players and thereby demonstrate that referees are able to keep pace with the players during FA Premier League matches.

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Introduction

English Premier League soccer referees cover match distances similar to those recorded by players (11.5 and 11.0 km, respectively) (Weston, Castagna, Helsen & Impellizzeri, 2009; Rampinini, Coutts, Castagna, Sassi & Impellizzeri, 2007). Indeed, Catterall, Reilly, Atkinson & Coldwells (1993) reported that a referee's activity was acyclical but varied in parallel with players' actions though no direct comparison was made between player and referee activity profiles in their study. In an attempt to quantify the relationship between intensities of exercise during matchplay in referees and players on the same matches, Weston, Castagna, Impellizzeri, Rampinini & Abt (2007) reported a moderate relationship between referees' and players' mean match high-intensity running distances. However, the analysis was performed on mean match distances and it might be that a more sensitive within-match analysis should be performed because it would improve understanding of patterns of exercise intensity (Drust, Atkinson & Reilly, 2007). Also, the comparison considered only players who completed entire matches (Weston et al., 2007). Given that substitutes perform more high-intensity running than other players towards the end of the match (Mohr, Krstrup & Bangsbo, 2003) this approach could not have accurately reflected intensities across entire matches.

The research designs and subsequent data interpretation associated with previous analyses of within-match exercise intensities in referees and players are not robust. For example, between-half distance comparisons on FA Premier League players (Rampinini et al., 2007) and referees (Weston et al., 2007) have reported decreased distances covered during the second half of matches. Yet these results could have been susceptible to the 'regression to the mean'

phenomenon (Atkinson, Waterhouse, Reilly & Edwards, 2001). Studies that have involved the categorisation of data into 15-min periods have reported a gradual decrease in high-intensity running across matches for players (Bradley et al., 2009) and referees (Krustrup & Bangsbo, 2001). However, the analyses associated with such research designs give no information about variation among participants in their response over time and comparisons at different time points are not independent (Matthews, Altman, Campbell & Royston, 1990). Adopting the approach of summary measures should help to overcome such issues in the analysis of within-match changes in exercise intensities as this method is statistically valid and more relevant to the research question: what are the rates of change of the outcome variable between groups (Matthews et al., 1990)?

Intensities of exercise during matchplay vary considerably (Gregson, Drust, Atkinson & DiSalvo, 2010) and Mohr et al. (2003) and Rampinini et al. (2007) both reported a seasonal effect for match running distances in soccer players; these distances being higher at the end of the season than at the start. Therefore, a comparison of intensities of exercise during matches across the duration of a competitive season is warranted if the relationship between referees and players is to be fully understood.

Hence, the aim of the current investigation was to provide a detailed examination of within-match and across-season rates of change in intensities of exercise during matchplay in elite-standard soccer referees and players.

Methods

Participants

Participants were 18 English Football Association (FA) Premier League referees. Data were collected from FA Premier League matches during the 2008/09 English soccer season. The mean age and body mass of the referees was 40 ± 5 years and 82.8 ± 10.0 kg, respectively. Written informed consent was received from all referees after verbal and written explanations of the experimental design. The local Institutional Review Board approved this study design.

Experimental Design

Match Exercise Intensities

The referees' intensities of exercise were examined for 236 matches (mean 13 ± 6 matches per referee). There was no incidence of referee injury during any of the matches. Each match was examined using a computerised, semi-automatic video match-analysis image recognition system (ProZone[®], Leeds, England). Recent findings have demonstrated that the ProZone[®] match-analysis system provides valid and reliable analysis of movement patterns of footballers during matchplay (Di Salvo, Collins, McNeill & Cardinale, 2006; Di Salvo, Gregson, Atkinson, Tordoff & Drust, 2009). The objective measures of exercise intensity selected for analysis were: 1) total distance covered (m); 2) high-speed running distance (speed >19.8 km.h⁻¹), and 3) sprinting distance (>25.2 km.h⁻¹).

The mean player intensities of exercise, also recorded via the ProZone[®] system, were calculated as the summation of the total distance, high-speed running and sprinting distances covered by each individual player on the field at the time during each 5-min period, divided by the total number of players (goalkeepers' data were excluded from the analysis). As such, this process accounted for player dismissals when the mean player distances were calculated. When a substitution was made in a particular 5-min period, data were recorded both for the replaced player and the substitute. This process allowed the overall match intensities to be evaluated inclusive of data from all substitutes. The total number of players involved in the study was 488.

To examine the relationship between the referees' and the players' intensities of exercise during matchplay each match was divided into 18 equal time periods (0-5 min, 6-10 min, 11-15 min, 16-20 min, 21-25 min, 26-30 min, 31-35 min, 36-40 min, 41-45 min, 46-50 min, 51-55 min, 56-60 min, 61-65 min, 66-70 min, 71-75 min, 76-80 min, 81-85 min and 86-90 min). Mean running distances were recorded for each of these periods. The periods of extra time at the end of each half were excluded from the analysis. The relationship between the referees' and the player's intensities of exercise during matchplay was examined for all 236 match observations.

Across-season variations in match exercise intensities were investigated by comparing the mean match running distances both for referees and players across the duration of the 2008/09 English Premier League soccer season (38 match days). To ensure that the data were representative of the entire season data were excluded if a referee did not have match data available in each of five

across-season categories ($n=206$ from a total of 13 referees [mean 16 ± 4 matches per referee]). These categories were August-September ($n=27$ matches [mean 2.1 ± 1.0 matches per referee]), October-November ($n=46$ matches [mean 3.7 ± 1.7 matches per referee]), December-January ($n=53$ matches [mean 4.1 ± 1.3 matches]), February-March ($n=33$ matches [mean 2.5 ± 1.1 matches per referee]) and April-May ($n=47$ matches [mean 3.6 ± 1.6 matches per referee]).

Statistical analyses

Data are presented as the mean \pm standard deviation. Before using parametric statistical test procedures, the assumption of data normality was verified. Pair-wise comparisons between referees' and players' mean match total distances, high-speed running and sprinting distances were made using a paired t-test. For the subsequent analyses we adopted the use of summary measures proposed by Matthews et al. (1990). The summary measure chosen was the regression coefficient (slope) given that the research question was an assessment of the rates of change of the outcome variable (match exercise intensities) between different groups (referees, players) (Matthews et al., 1990). Therefore for within-match comparisons linear regressions were calculated for each referee and each mean player running distances (total, high-speed running and sprinting) during each 5-min period across the duration of the referees' matches (see figure 1A for an individual example). For across-season comparisons linear regressions were calculated on the referees' mean and player mean match running distances during each of the referees' matches across the season (see figure 1B for an individual example). Pearson's r was calculated on the relationship between referee and player slope values. The following scale of magnitudes proposed by Hopkins (www.sportsci.org) was used to interpret the

correlation coefficients: <0.1, trivial; 0.10-0.29, small; 0.30-0.49, moderate; 0.50-0.69, large; 0.70-0.90, very large; >0.9, nearly perfect. Differences between referees' and mean player slope values were checked for data normality. Paired t-tests were then used to compare the slopes of the distance-time individual regression lines for referees and players. The same procedure was used to examine across-season changes in match exercise intensities between referees and players. Effect sizes (Cohen's *d*) for between-group differences were determined, with values of <0.50, 0.50-0.79 and >0.80 representing a small, moderate and large difference, respectively. Statistical significance was set at $p < 0.05$. All calculations were performed using the SPSS analysis software package (Version 16).

Results

The referees' total distance was greater than the players' distance (11280 ± 738 m vs. 10794 ± 374 m, $p < 0.001$, $d = 0.83$). There were no between-group differences for high-speed running (716 ± 238 m vs. 703 ± 94 m, $p = 0.350$, $d = 0.07$). The players' sprinting distance was greater than that recorded by the referees (153 ± 108 m vs. 262 ± 74 m, $p < 0.001$, $d = 1.31$).

The referees' and players' mean total distance covered, high-speed running and sprinting distance during each 5-min period are presented in Figure 2. There were large correlations between referee and player slope values for total distance-time ($r = 0.664$, $p = 0.003$) and also high-speed running-time slope values ($r = 0.624$, $p = 0.006$), with a small correlation for the sprinting-time slope values ($r = -0.239$, $p = 0.340$). The referees' total distance (-0.594 ± 0.394 vs. -0.713 ± 0.269 m.min⁻¹, $p = 0.104$, $d = 0.35$), high-speed running (-0.039 ± 0.077 vs. -

$0.059 \pm 0.030 \text{ m}\cdot\text{min}^{-1}$, $p=0.199$, $d = 0.34$) and sprinting-time regression slope values (-0.003 ± 0.039 vs. $-0.021 \pm 0.017 \text{ m}\cdot\text{min}^{-1}$, $p=0.114$, $d = 0.60$) did not differ from the mean player values.

The referees' and players' mean intensities of exercise during matchplay over the duration of the 2008/09 English Premier League season are presented in Figure 3. There were large correlations between the referee and player slope values for total distance-match day ($r=0.664$, $p=0.013$) and sprinting-match day ($r=0.580$, $p=0.038$). The mean value of the referees' total distance-match day (-26.756 ± 40.434 vs. $-20.031 \pm 25.502 \text{ m}\cdot\text{match day}$, $p=0.439$, $d = 0.20$) and sprinting-match day regression slopes (-9.662 ± 7.564 vs. $-8.589 \pm 4.351 \text{ m}\cdot\text{match day}$, $p=0.542$, $d = 0.17$) did not differ from the mean player responses. However, the referees' and players' high-speed running-match day regression slopes were different (-15.906 ± 9.712 vs. $-9.120 \pm 5.108 \text{ m}\cdot\text{match day}$, $p=0.004$, $d = 0.87$), despite a very large correlation between the referees' and players' high-speed running-match day slope values ($r=0.729$, $p=0.005$).

Discussion

The aim of the current investigation was to provide a detailed examination of the relationship between intensities of exercise during matchplay in FA Premier League referees and players. We report for the first time that within-match rates of change in total distance covered, high-speed running and sprinting were consistent between referees and the mean player responses for the same matches. We were also able to demonstrate that the across-season rates of change in total distance covered and sprinting were consistent between

referees and players. Despite between-group differences for across-season high-speed running slope values there was a very large correlation. These results show that elite-standard soccer referees' intensities of exercise during matchplay are interrelated with those of the players and thereby demonstrate that referees are able to keep pace with the players during FA Premier League matches.

To date, the only attempt to quantify the relationship between intensities of exercise during matchplay in referees and players on the same matches reported a moderate relationship between mean match high-intensity running distances (Weston et al., 2007). The authors concluded that referees' physical performances are in part related to those of the players for the same match. However, this analysis was performed on mean match running distances and the player data considered only players who completed entire matches. Such an approach could not have accurately reflected match intensity given that substitutes perform more high-intensity running than other players towards the end of the match (Mohr et al., 2003). Through the comparison of the rates of change in intensities of exercise across each 5-min match period, we have demonstrated that within-match rates of change in exercise intensities are consistent between referees and the mean player response for the same match. This more sensitive analysis demonstrates a stronger relationship between referee and player match exercise intensities than previously reported (Weston et al., 2007). We have also demonstrated that across-season changes in total distance covered and sprinting were consistent between referees and players. This finding further highlights the strength of the relationship between the match activities of referees and players.

The differences in the referees' and players' volume and intensities of running reflect primarily the role-specific nature of referees and players during matches. Specifically, referees have to keep up with play at all times to minimise the number of incorrect judgments (Weston, Helsen, MacMahon & Kirkendall, 2004) as considerable distances from fouls can lead to such decisions (Krustrup & Bangsbo, 2001). Positional requirements of players impact upon their involvement in the match and in turn the intensity of exercise. For example, DiSalvo et al. (2009) reported that the total high-intensity running during FA Premier League matches depended on playing position with wide midfield and central defenders completing the highest and lowest distances, respectively. Differences in sprinting distance could also be a consequence of the use of universally applied speed thresholds. Given the age difference between elite-standard referees and players (Catterall et al., 1993), players should well be expected to possess greater physical abilities, especially given the previously reported age-related decrement in soccer referees' all-out exercise performance (Castagna, Abt, D'Ottavio & Weston, 2005). Therefore, the reporting of distances covered in speed zones relative to individual fitness would serve to give an even better estimate of the physical comparison.

Previous studies that have reported a gradual decrease in high-intensity running throughout matches both for players (Bradley et al., 2009) and referees (Krustrup & Bangsbo, 2001) have attributed the decrease to fatigue. However, on certain occasion's players do not use their full capabilities and factors such as tactical changes are involved in the inherent variation observed in soccer (Drust, Atkinson & Reilly, 2007). Consequently, it is difficult to determine the

extent to which the referees in the present study were fatiguing during match-play since the data suggest that their intensity of exercise is driven by that of players.

As far as we are aware, this is the first study that has examined changes in referees' and players' intensities of exercise during matchplay over the duration of a season by keeping the data continuous across the entire season. The negative slope values for all measures both for referees and players illustrate reduced match exercise intensity over the duration of the season. These results are in contrast to those previously reported for players (Mohr et al., 2003; Rampinini et al., 2007) and referees (Weston et al., 2007). Differences among the reported findings could partly be associated with the statistical power of the studies as Mohr et al. (2003) and Rampinini et al. (2007) both used smaller sub-groups for the comparisons and there is further possible loss of statistical power in these studies because of the categorisation of a continuous variable (Altman & Royston, 2006).

It is unlikely that changes in physical fitness would explain the entire variation in exercise intensities across a season as variability is noted when observations are completed in short time spans (Drust, Atkinson & Reilly, 2007). Also, during the competitive season players' physical capabilities tend to remain stable at least at group level (Impellizzeri et al., 2008). Therefore, whether or not across-season changes in the players' exercise intensities were the consequence of fatigue accumulated in the first part of the competitive season (Impellizzeri et al., 2008) or during periods of fixture congestion, changes in fitness or merely a slower tempo of match remains unclear. Consequently, it is difficult to determine

if such factors also influenced the seasonal variation in the referees' match exercise intensities or if the decreased intensities were purely a consequence of the players' reduction.

In summary, the results of this study show for the first time that elite-standard soccer referees' intensities of exercise during matchplay are interrelated with those of the players. Specifically, despite differences in total distance covered and sprinting distance, within-match rates of change in match exercise intensities were consistent between referees and players. This consistency was also evident across-season with the exception of high-speed running. As such it is evident that soccer referees are able to keep pace with the players and consequently referees' intensities of exercise during matchplay should be interpreted alongside players' intensities.

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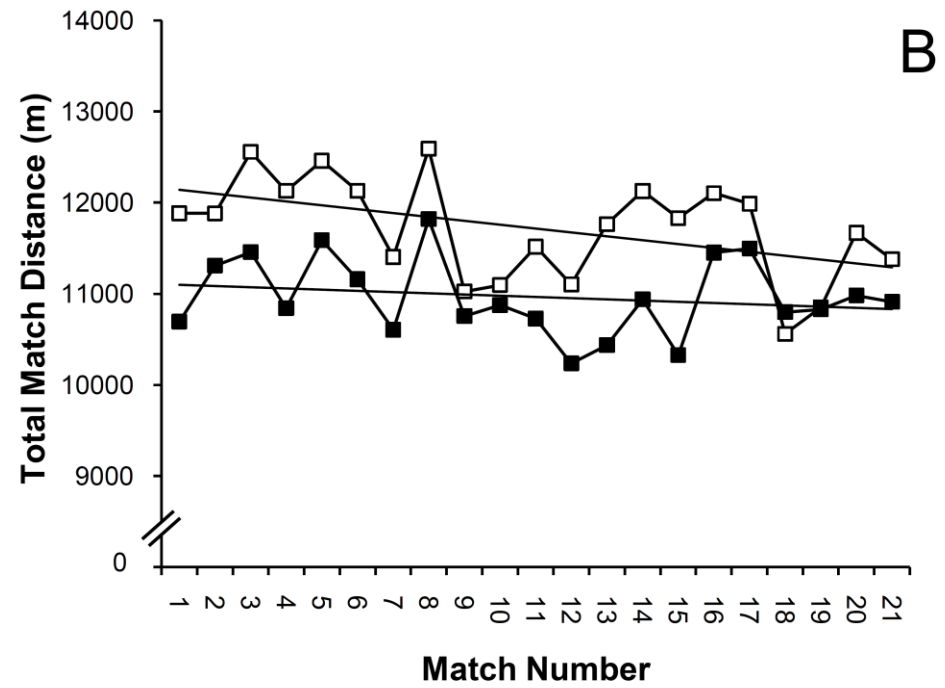
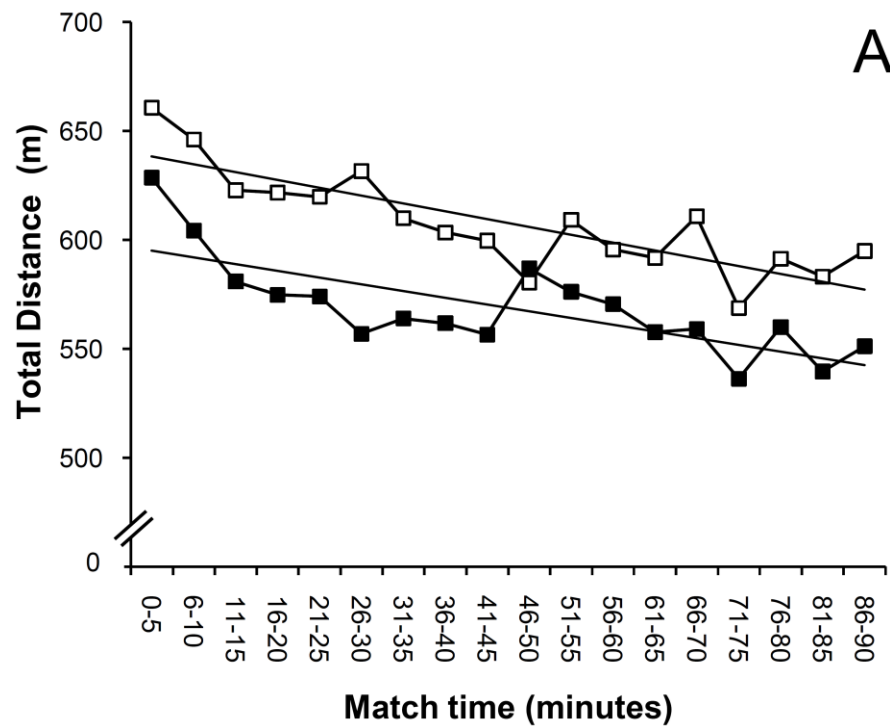


Figure 1 Example of within-match (A) and across-season (B) linear regressions for an individual referee (open symbols) and the mean player data (closed symbols) on the same matches.

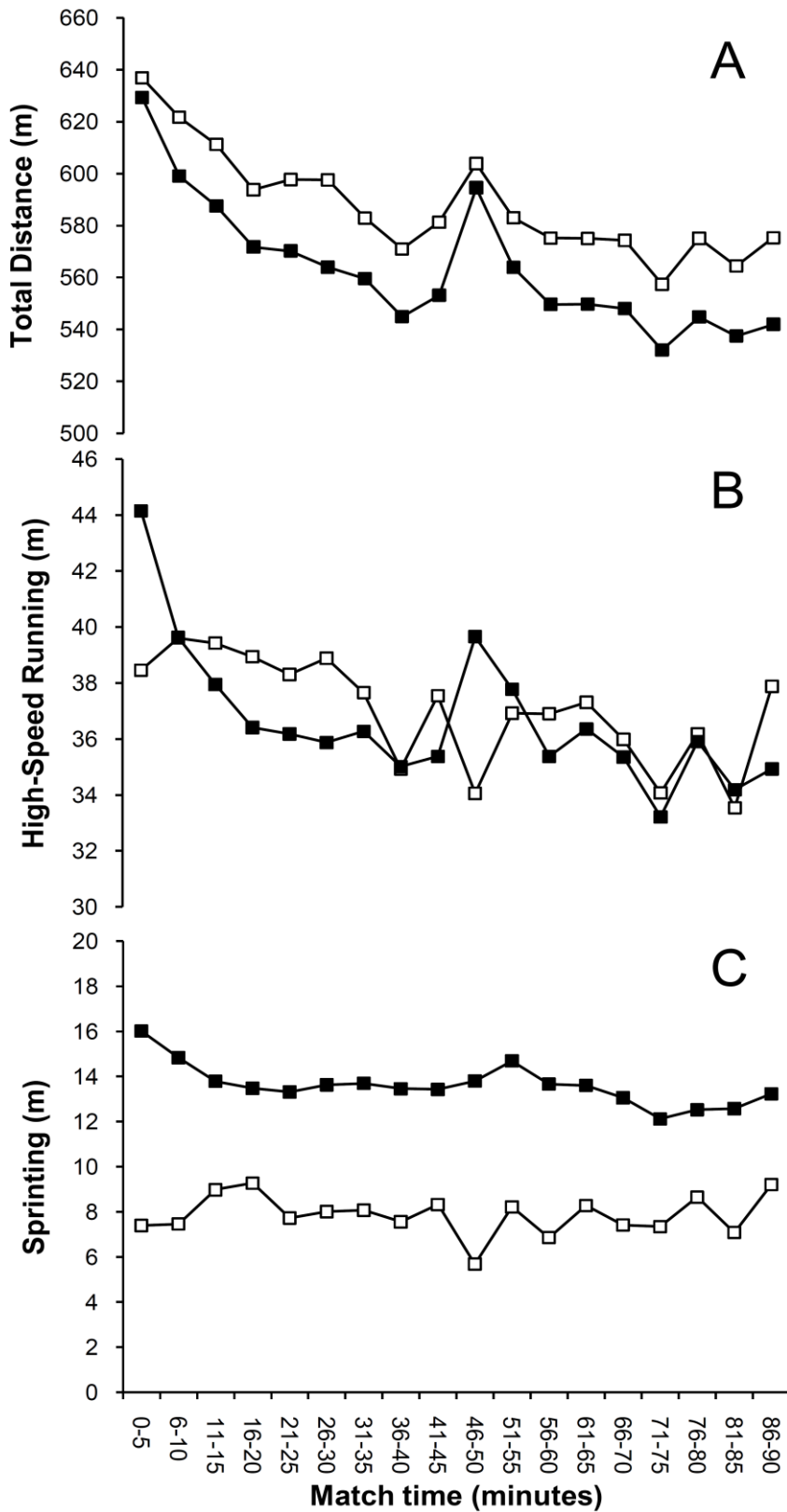


Figure 2 Total distance (A), high-speed running (B) and sprinting (C) both for referees (open symbols) and players (closed symbols) across the 18 5-min match periods (error bars omitted for figure clarity)

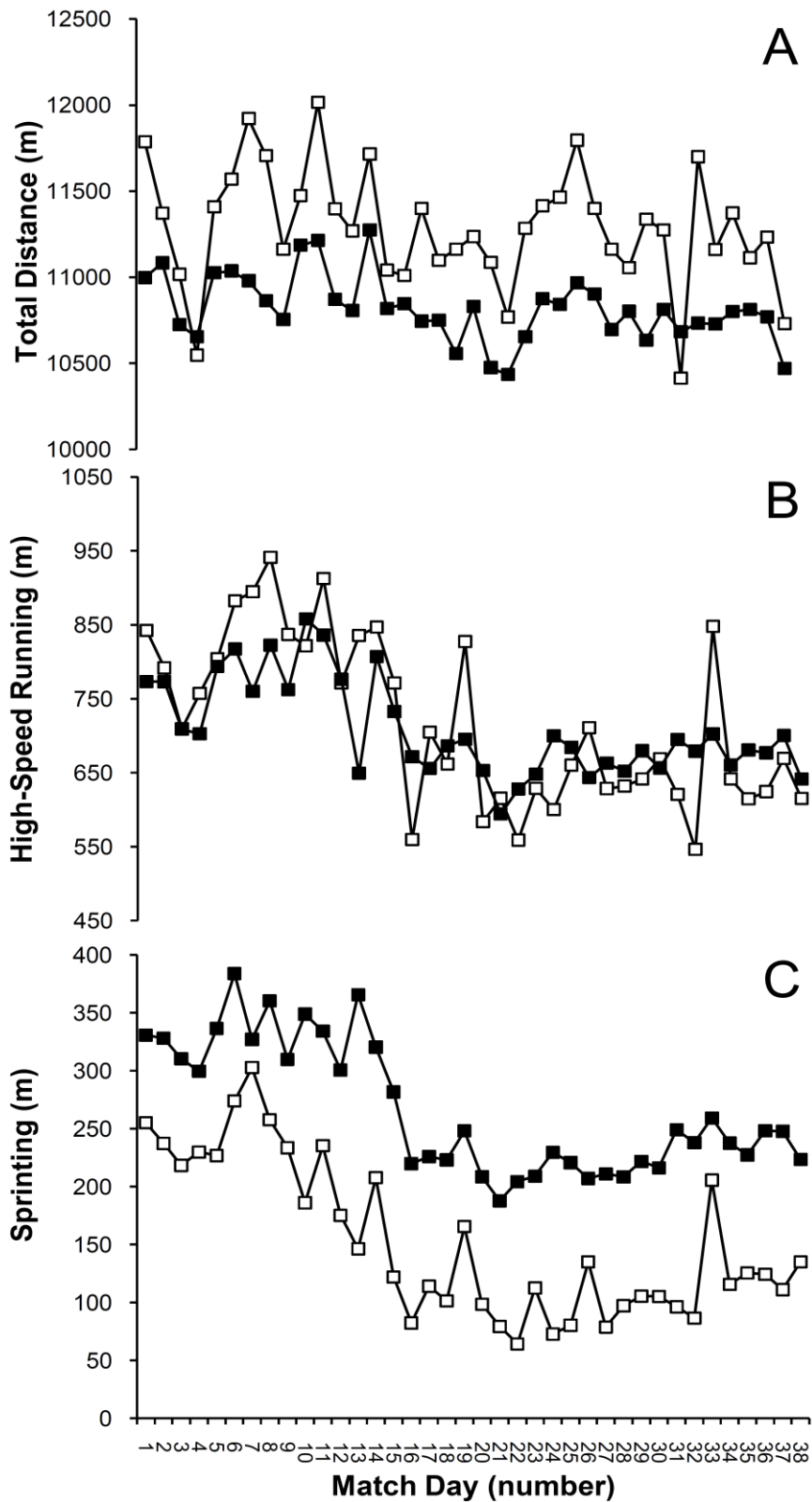


Figure 3 Mean match day total distance (A), high-speed running (B) and sprinting (C) both for referees (open symbols) and players (closed symbols) across the duration of the 2008/09 English Premier League season (error bars omitted for figure clarity)