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Variations in locomotor intensities across soccer match halves concerning player sectorial positions

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ABSTRACT
Purpose. This study aims to explore disparities in locomotor metrics such as total distance (TD), high-speed running (HSR), accelerations (Acc), decelerations (Dec), and maximum speed (MS) across five soccer positions – centre defenders, fullbacks, midfielders, wingers, and forwards – during the 1-, 3-, and 5-minute match intensity periods (MIP). Additionally, it seeks to assess the difference in those locomotor metrics between the first and second halves of the match.
Methods. An observational, retrospective cohort study was undertaken with a professional team covering 32 official matches. A total of 20 soccer players participated in this study. Data were collected using a 10-Hz GNSS unit (Apex pro series, StatSports, Northern Ireland). The MIP considered different time durations (1, 3, 5 min in the 1st and the 2nd halves).
Results. Soccer players exhibited position-specific differences in locomotion, with Wingers covering the most distance and forwards showing the highest Acc and Dec. HSR was most notable in the fullbacks. The second half saw varied changes, with midfielders increasing in distance covered. ANCOVA revealed significant positional differences in TD during longer MIPs and between match halves. HSR varied across positions but only differed between halves in the 5-minute MIP. Acc and Dec displayed half-time differences, while maximal speed was consistently higher in the second half.
Conclusions. This study highlights the impact of player position and matches progression on locomotor metrics in soccer, underscoring the need for customised training and strategic adaptability to maximise performance throughout the game.
Key words: soccer, match demands, maximal intensity periods, performance, global positioning system

Introduction

In soccer, time-motion analysis has greatly interested researchers and practitioners in characterising players' activities [1]. In recent decades, global positioning systems (GPS) have emerged as crucial external load monitoring tools, frequently used in training sessions and matches [2]. In a previous investigation on the locomotor activities of soccer players competing in four European Football Association Cup matches, the authors reported an average total distance (TD) covered of 11,288 ± 734 m, with midfielders (MDs) accounting for the longest average distance (11,770 ± 554 m) [3]. In another study, MDs presented a higher maximal speed running distance (140.1 ± 7.5 km/h) than forwards (FWs) (133.8 ± 15.3 km/h) and defenders (DFs) (126.5 ± 6.4 km/h) [4]. Indeed, most studies have reported that MDs produced the highest TD, while FWs presented

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the highest number of high-speed running (HSR) actions [5, 6]. Based on GPS data, the soccer literature has investigated the players' activity profiles following match demands. This information is of great interest to coaches and their staff, particularly for adopting training strategies consistent with game performance [2].

However, considering a segmental approach of the data relating to the intensity based on the average of the entire matches, halves, or specific time durations (i.e., 0 to 5, 5 to 10 min) may lead to an underrepresentation of the higher levels of intensity, due to the presence of several periods of inactivity [7, 8]. In this way, a moving average approach has been proposed as a more viable strategy to analyse the maximal intensity experienced by players during matches [9, 10]. This method has been used in several studies with specific time durations to understand the maximum intensity experienced by players [11–13]. Although it has been used with different nomenclatures in the literature, we will refer to it as maximum intensity periods (MIP).

Some studies that have analysed the MIP of matches have used several specific time intervals (i.e., 1, 3, 5 min or more) [11, 13, 14]. What was observed in studies that analysed several time intervals was that, usually, as these time intervals increase, the intensity of the observed variables decreases. Therefore, the different time intervals have distinct characteristics and are possibly influenced by fatigue [15]. The analysis of different periods relating to MIP could also provide helpful information for the coaches and their team staff, providing benchmarks that can guide training and replicate the intensity experienced by players during actual matches [13]. This information can also be analysed depending on each field position's unique characteristics, enhancing the training plan's quality, and ultimately impacting the player's preparation for the specific demands of their respective match positions [1, 11]. In addition to the analysis of short MIP periods, the comparison between different halves of the matches has also shown some variations regarding external load [16, 17]. For example, among U19 soccer players, TD significantly decreased from the 1st to the 2nd half of the match in four playing positions (full-back, central midfielder, winger, and striker) [16]. In another investigation conducted in the Spanish 1st Division, the authors described that performance indicators at very high intensities decreased between match halves, except for the central defenders [17].

All this information regarding MIP, especially when considering HSR, accelerations (Acc) and decelerations (Dec), is of great interest to coaches and their staff due to its relationship with the risk of injury [18, 19]. Indeed, variations in load and locomotor activities may predispose different playing positions to different injury rates [20]. Although research on this topic is still scarce, it seems that there is a tendency for FWs to be at higher risk of match injuries when compared to other playing positions [20].

The growing interest in performance analysis at different match periods is sustained by the valuable data provided on players' profiles. This information is crucial for coaches and their staff in designing training sessions, selecting tactical decisions, and preventing injury. Although some studies have already analysed locomotor activity according to different periods of MIP, to our knowledge, none has been carried out in the specific context of the Portuguese 1st league. Therefore, the purpose of this study was to investigate differences in locomotor variables (i.e., TD, HSR, Acc, Dec, and MS) among five field positions (i.e., centre defenders, fullbacks, midfielders, wingers, and forwards) during the 1-, 3-, and 5-min MIP. Additionally, it seeks to assess the variation of those locomotor metrics between the first and second halves of the match. Based on previous research, the following hypothesis was formulated for the current study: significant differences are anticipated in locomotor variables – specifically TD, HSR, Acc, Dec, and MS – across centre defenders, fullbacks, midfielders, wingers, and forwards during the 1-, 3-, and 5-min MIP in the second half of the match. These differences will be examined while controlling for locomotor variables in the first half and are expected to reflect the distinct physical demands, fatigue levels, or tactical adjustments unique to each position, between halves.

Material and methods

Design and participants

An observational, retrospective cohort study was undertaken with a professional team from the Portuguese first league during the 2021–2022 soccer season, covering 32 official matches at home and away. A total of 20 soccer players participated in this study. A cross-sectional analysis was carried out for the present study. A total of 298 observations were considered in the analyses. Players were independently entered into the database for each game, contributing to a comprehensive sample of observations, including 67 for centre defenders (CDs), 60 for fullbacks (FBs), 75 for midfielders (MDs), 44 for wingers (WGs), and 52 for forwards (FWs). Players who participated in the match and were on the field for 60 or more minutes were included, and the goalkeepers were the only position excluded. The matches lasted ~90 minutes, separated by two halves of ~45 minutes. All procedures were approved by the Faculty of Human Kinetics Ethics Committee, CEIFMH N° 34/2021. The investigation was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from all players.

Locomotor demands

Players' movements were recorded during each official match using a 10-Hz GNSS unit (Apex pro series, STATSports, Northern Ireland). These devices contain a 100 Hz gyroscope, a 100 Hz tri-axial accelerometer, and a 10 Hz magnetometer. Also, as a multi-GNSS, they can acquire and track multiple satellite systems (i.e., global positioning systems, GLONASS). The accuracy and validation of these devices have already been presented with acceptable levels of accuracy, only reporting a small error of around 1–2% for distances covered and velocity peak [21]. The STATSports Sonra software calculated the moving average using different time durations (1-min, 3-min, 5-min, and the two halves of matches). The epoch length for the peak locomotor demands was chosen according to the study of Casamichana, Castellano, Diaz, Gabbett and Martin-Garcia [11]. This process was carried out for each of the following criterion variables: TD, distance HSR (above $5 \text{ m} \cdot \text{s}^{-1}$), total Acc ($< 3 \text{ m} \cdot \text{s}^{-2}$), total Dec ($< 3 \text{ m} \cdot \text{s}^{-2}$) and MS reached by the players. The GNSS device was used in a skin-tight bag in the thoracic region between the scapulae. Each player used the same device during the season to avoid interunit errors [22, 23].

Statistical analysis

Descriptive statistics (mean and standard deviation) were used to summarise the data collected. A one-way between-groups analysis of covariance was conducted to examine the differences in locomotor variables between the 1st and 2nd halves of the match across each specific field position for each different MIP. The independent variable was the 5-field positions (i.e., CDFs, FBs, MDs, WGs, and FWs), and the dependent variables were the 5 locomotor variables analysed (i.e., TD, HSR, Acc, Dec, and MS). Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, or reliable measurement of the covariate. All analyses were performed using IBM SPSS Statistics software 28.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at 5%.

Results

Table 1 provides a summary of locomotor variables for different field positions in soccer, comparing the first and second halves of a match. These variables include TD, HSR, Acc, Dec, and MS. In the first half, the CDFs, FBs, MDs, WGs, and the FWs showed varied performance levels in TD, with WGs covering the most ground (208.0 ± 53.8 m at 1 min, 463.2 ± 33.2 m at 3 min, and 709.7 ± 45.5 m at 5 min). For HSR, the FBs demonstrated the highest distances at 1- and 3-min intervals. In terms of Acc and Dec, the FWs logged the highest number of accelerations at the 5-min interval (5.6 ± 2.2). Decelerations also followed this trend, with the FWs registering the most at the 5-min mark (7.3 ± 2.4). MS was relatively stable across all positions, with a slight increase observed in the second half for most positions. In the 2nd half, the performance slightly decreased in TD for the CDFs but increased for other positions, with the MDs covering the most at 5 min (671.8 ± 37.4 m). HSR slightly decreased for the CDFs remained consistent for the FBs, and increased for the other positions, with the WGs peaking at 3 min (105.1 ± 36.7 m). Acc and Dec displayed a similar pattern to the 1st half, with slight variations between positions. MS remained consistent or slightly increased in the 2nd half.

The one-way ANCOVA results in Table 2 show differences in locomotor variables between specific field positions and between the first and second halves of matches during 1-, 3- and 5-min MIPs. For TD, significant differences were found between the specific field positions during the 3-min and 5-min MIPs [$F(4, 290) = 10.44$, $p < 0.001$, $\eta_p^2 = 0.16$, and $F(4, 290) = 9.88$, $p < 0.001$, $\eta_p^2 = 0.12$, respectively], but not during the 1-min MIP [$F(4, 289) = 1.38$, $p = 0.24$]. Additionally, significant differences were found between the first and second halves during the 3-min and 5-min MIPs [$F(1, 290) = 54.72$, $p < 0.001$, $\eta_p^2 = 0.33$, and $F(1, 290) = 53.78$, $p < 0.001$, $\eta_p^2 = 0.16$], but not during the 1-min MIP [$F(1, 289) = 0.01$, $p = 0.92$]. For HSR, there were significant differences between field positions during all MIPs [1-min: $F(4, 290) = 3.52$, $p = 0.01$; 3-min: $F(4, 290) = 3.31$, $p = 0.01$; 5-min: $F(4, 290) = 6.38$, $p < 0.001$]. However, differences between halves were only significant during the 5-min MIP [$F(1, 290) = 13.25$, $p < 0.001$]. For Acc, no significant differences were found between field positions across any MIPs, though there was a trend towards significance in the 5-min MIP [$F(4, 290) = 2.04$, $p = 0.09$]. A significant difference was observed between halves in the 5-min MIP [$F(1, 290) = 4.12$, $p = 0.04$]. Dec also did not show sig-

Table 1. Descriptives in locomotor variables between each specific field position and between the 1st and 2nd halves of the match for each MIP

Variable	1st half						2nd half					
	CDFs [1] (mean ± *SD*)	FBs [2] (mean ± *SD*)	MDs [3] (mean ± *SD*)	WGs [4] (mean ± *SD*)	FWs [5] (mean ± *SD*)	*p*	CDFs [1] (mean ± *SD*)	FBs [2] (mean ± *SD*)	MDs [3] (mean ± *SD*)	WGs [4] (mean ± *SD*)	FWs [5] (mean ± *SD*)	*p*
1 min												
TD (m)	173.5 ± 41.0	201.4 ± 46.8	206.1 ± 48.3	208.0 ± 53.8	197.8 ± 45.7	< 0.001	175.9 ± 70.2	204.1 ± 85.0	209.4 ± 97.8	205.9 ± 79.3	200.6 ± 104.4	0.195
HSR (m)	40.9 ± 23.3	63.4 ± 27.1	52.8 ± 28.9	55.9 ± 21.4	49.3 ± 18.6	< 0.001	44.3 ± 22.7	61.2 ± 27.1	44.2 ± 26.1	51.0 ± 23.0	50.2 ± 29.0	0.001
Acc (n)	1.4 ± 1.1	1.3 ± 1.0	1.0 ± 1.0	1.5 ± 1.3	1.3 ± 1.1	0.186	1.5 ± 1.3	1.7 ± 1.2	1.2 ± 1.1	1.4 ± 1.1	1.8 ± 1.3	0.083
Dec (n)	1.6 ± 1.2	1.9 ± 1.0	1.6 ± 1.1	1.9 ± 1.1	2.1 ± 1.3	0.052	1.9 ± 1.4	1.8 ± 1.3	1.5 ± 1.3	2.0 ± 1.4	1.7 ± 1.6	0.486
MS (km/h)	26.0 ± 3.2	27.1 ± 3.6	25.1 ± 3.0	27.0 ± 3.0	27.0 ± 3.6	< 0.001	26.3 ± 3.2	27.3 ± 3.2	24.5 ± 3.3	25.5 ± 3.4	26.3 ± 3.5	< 0.001
3 min												
TD (m)	394.2 ± 34.3	441.2 ± 21.5	467.9 ± 24.4	463.2 ± 33.2	444.5 ± 27.7	< 0.001	384.0 ± 30.9	429.2 ± 22.8	443.0 ± 26.0	452.0 ± 41.1	419.7 ± 28.1	< 0.001
HSR (m)	46.7 ± 24.2	84.2 ± 34.8	67.1 ± 31.2	74.9 ± 34.3	71.4 ± 22.5	< 0.001	58.3 ± 32.2	78.1 ± 28.9	63.6 ± 32.3	71.3 ± 29.8	72.9 ± 32.9	0.004
Acc (n)	3.0 ± 1.8	3.4 ± 1.5	2.7 ± 1.8	3.1 ± 1.9	3.5 ± 1.7	0.111	3.0 ± 1.9	3.1 ± 1.7	2.7 ± 1.6	3.2 ± 1.5	3.5 ± 1.7	0.096
Dec (n)	3.3 ± 1.7	4.3 ± 2.0	4.1 ± 1.9	4.3 ± 2.0	4.7 ± 1.7	0.001	3.3 ± 1.6	3.8 ± 1.6	3.5 ± 1.7	4.4 ± 1.7	3.7 ± 1.7	0.016
MS (km/h)	26.1 ± 3.4	27.3 ± 3.1	25.1 ± 2.7	27.1 ± 3.6	27.5 ± 2.8	< 0.001	26.5 ± 3.5	27.2 ± 3.1	25.4 ± 3.1	26.7 ± 3.1	27.0 ± 2.8	0.007
5 min												
TD (m)	614.4 ± 55.4	675.3 ± 35.9	725.8 ± 38.3	709.7 ± 45.5	683.0 ± 42.1	< 0.001	586.2 ± 47.3	654.2 ± 36.1	671.8 ± 37.4	689.0 ± 78.5	641.3 ± 43.5	< 0.001
HSR (m)	67.3 ± 30.0	108.8 ± 34.1	92.3 ± 40.9	100.0 ± 38.0	95.1 ± 29.5	< 0.001	67.7 ± 34.7	105.1 ± 36.7	82.0 ± 37.4	102.5 ± 37.2	90.0 ± 33.2	< 0.001
Acc (n)	4.6 ± 2.2	4.9 ± 2.2	4.1 ± 2.0	5.1 ± 2.3	5.6 ± 2.2	0.002	4.4 ± 2.2	4.6 ± 2.1	3.8 ± 2.5	4.7 ± 2.4	5.0 ± 2.0	0.022
Dec (n)	5.0 ± 2.2	6.5 ± 2.9	6.7 ± 2.7	6.7 ± 2.6	7.3 ± 2.4	< 0.001	4.7 ± 2.3	5.9 ± 2.1	5.2 ± 2.5	6.1 ± 2.2	5.6 ± 2.1	0.005
MS (km/h)	26.7 ± 3.4	28.1 ± 2.6	25.6 ± 2.5	27.5 ± 3.2	27.5 ± 3.1	0.061	26.4 ± 3.6	27.8 ± 2.7	25.9 ± 2.8	27.5 ± 3.1	27.8 ± 2.8	0.026

CDFs – centre defenders, FB – fullbacks, MDs – midfielders, WGs – wingers, FWs – forwards, TD – total distance, HSR – high-speed running, Acc – accelerations, Dec – decelerations, MS – maximal speed

Table 2. Differences in locomotor variables between each specific field position and between the 1st and 2nd halves of the match for each MIP

Locomotor variables		Maximal intensity periods		
		1 min	3 min	5 min
TD (m)	SfP-Diff	$F(4, 289) = 1.38$, $p = 0.24$, $\eta_p^2 = 0.02$	$F(4, 290) = 10.44$, $p < 0.001$, $\eta_p^2 = 0.16$	$F(4, 290) = 9.88$, $p < 0.001$, $\eta_p^2 = 0.12$
	1st vs 2nd half	$F(1, 289) = .01$, $p = 0.92$, $\eta_p^2 = 0.00$	$F(1, 290) = 54.72$, $p < 0.001$, $\eta_p^2 = 0.33$	$F(1, 290) = 53.78$, $p < 0.001$, $\eta_p^2 = 0.16$
HSR (m)	SfP-Diff	$F(4, 290) = 3.52$, $p = 0.01$, $\eta_p^2 = 0.05$	$F(4, 290) = 3.31$, $p = 0.01$, $\eta_p^2 = 0.04$	$F(4, 290) = 6.38$, $p < 0.001$, $\eta_p^2 = 0.08$
	1st vs 2nd half	$F(1, 290) = 3.31$, $p = 0.07$, $\eta_p^2 = 0.01$	$F(1, 290) = 0.02$, $p = 0.90$, $\eta_p^2 = 0.00$	$F(1, 290) = 13.25$, $p < 0.001$, $\eta_p^2 = 0.04$
Acc (n)	SfP-Diff	$F(4, 290) = 1.89$, $p = 0.11$, $\eta_p^2 = 0.03$	$F(4, 290) = 1.88$, $p = 0.11$, $\eta_p^2 = 0.03$	$F(4, 290) = 2.04$, $p = 0.09$, $\eta_p^2 = 0.03$
	1st vs 2nd half	$F(1, 290) = 1.85$, $p = 0.18$, $\eta_p^2 = 0.03$	$F(1, 290) = 0.09$, $p = 0.77$, $\eta_p^2 = 0.00$	$F(1, 290) = 4.12$, $p = 0.04$, $\eta_p^2 = 0.01$
Dec (n)	SfP-Diff	$F(4, 290) = .86$, $p = 0.49$, $\eta_p^2 = 0.01$	$F(4, 290) = 2.46$, $p = 0.04$, $\eta_p^2 = 0.03$	$F(4, 290) = 2.59$, $p = 0.03$, $\eta_p^2 = 0.03$
	1st vs 2nd half	$F(1, 290) = 1.64$, $p = 0.20$, $\eta_p^2 = 0.01$	$F(1, 290) = 11.59$, $p < 0.001$, $\eta_p^2 = 0.04$	$F(1, 290) = 11.55$, $p < 0.001$, $\eta_p^2 = 0.04$
MS (km/h)	SfP-Diff	$F(4, 290) = 5.75$, $p < 0.001$, $\eta_p^2 = 0.07$	$F(4, 290) = 3.39$, $p = 0.01$, $\eta_p^2 = 0.05$	$F(4, 290) = 3.63$, $p = 0.01$, $\eta_p^2 = 0.05$
	1st vs 2nd half	$F(1, 290) = 5.55$, $p = 0.02$, $\eta_p^2 = 0.02$	$F(1, 290) = 0.03$, $p = 0.87$, $\eta_p^2 = 0.00$	$F(1, 290) = 5.38$, $p = 0.021$, $\eta_p^2 = 0.02$

SfP-Diff – differences between the five specific field positions, 1st vs 2nd halves – differences between the 1st and the 2nd halves of the game nificant differences between field positions in the 1-min MIP but did in the 3-min and 5-min MIPs [$F(4, 290) = 2.46$, $p = 0.04$, and $F(4, 290) = 2.59$, $p = 0.03$, respectively]. Significant differences between halves were observed in the 3-min and 5-min MIPs [$F(1, 290) = 11.59$, $p < 0.001$, and $F(1, 290) = 11.55$, $p < 0.001$, respectively]. Lastly, for MS, significant differences between field positions were noted across all MIPs [1-min: $F(4, 290) = 5.75$, $p < 0.001$; 3-min: $F(4, 290) = 3.39$, $p = 0.01$; 5-min: $F(4, 290) = 3.63$, $p = 0.01$]. Between the halves, significant differences were observed during the 1-min and 5-min MIPs [$F(1, 290) = 5.55$, $p = 0.02$, and $F(1, 290) = 5.38$, $p = 0.021$, respectively] but not during the 3-min MIP.

Discussion

This study reveals significant variability in soccer players' locomotor performance across positions and match halves. Notably, performance often dipped in the second half for the CDs but improved for the MDs in distance covered. The ANCOVA results showed significant positional differences in distance during longer-intensity periods and between halves, except for the shortest period. HSR differences were consistent across positions and time, but only the 5-min interval showed differences between halves. Accelerations showed no positional differences but did between halves at the 5-min MIP. Maximum Speed was stable, with slight inter-half increases. These findings suggest position-specific demands affecting performance, with practical implications for training and match strategy.

Prior research has documented variations in peak performance metrics among players based on their field positions [1, 11, 12]. In this study, the MDs and WGs consistently covered more ground than players in all other field positions assessed. This trend was evident in both halves during the 3- and 5-min MIP time windows. Conversely, the FWs and FBs exhibited significantly higher values than the DFs during the 3- and 5-min time windows. This aligns with findings from previous studies conducted by Delaney et al. [24], Martín-García et al. [13] and Lacome et al. [25], which examined MIP by player positions. These earlier studies consistently showed that the MDs recorded the highest values for TD covered in matches, while the DFs had the lowest. For example, Martín-García et al. [13] reported that the MDs reached values as high as 200 m/min. Our study corroborates these findings, with the MDs achieving average values of 206.1 m/min in the 1st half and 209.4 m/min in the 2nd half. These values underscore the demanding role of MDs, especially WGs, who, due to the multifaceted nature of their position, involving actions such as ball recovery and providing both offensive and defensive support, need to cover more ground, resulting in greater distances covered [1].

Regarding the HSR, a consistent pattern emerged since the FBs, WGs and FWs consistently displayed higher values than the CDs. This discrepancy was notable during MIP across various time windows and became especially apparent during the 2nd halves of matches. These findings highlight the demands placed on FBs, WGs and FWs in soccer. They engage in high-intensity explosive actions, whether pressing the opposing defence or attacking the opponent's goal, leading to extended HSR periods [1]. This trend aligns with previous research by Delaney et al. [24] and Martín-García et al. [13], which found that FWs and FBs exhibit higher HSR values. This might be attributed to the nature of the fullback position, which requires explosive actions both in attack and defence, necessitating high-intensity efforts. Recognising the variations in HSR values among different player positions is crucial and can lead to more effective training, injury prevention, and match management strategies, ultimately benefiting player performance and well-being in soccer [26, 27].

The data on Acc and Dec also revealed interesting insights. No significant positional differences in accelerations were found, but 2nd half increases in Dec were significant during longer maximal intensity periods. This suggests that players tend to perform a similar number of Acc and Dec during small intervals regardless of their role on the field. For Acc and Dec, significant increases were noted across all player positions from the 1st to the 2nd half, particularly in the 5-min MIP, with the FWs and WGs consistently showing the highest values. These findings diverge from prior studies conducted by Delaney et al. [24] and Martín-García et al. [13], where the FWs presented lower values for Acc and Dec during matches. It is important to note that these earlier studies analysed players' positions more specifically, encompassing both strikers and WGs. This distinction may explain the variance in results, as WGs, due to the unique demands of their role, often engage in rapid Acc when positioning themselves for crosses or attempting goals. Consequently, their presence within the FWs group likely contributed to increased Acc and Dec. As a result, it may be beneficial for WGs to receive specific training targeting these actions, given their frequent occurrence in these positions during matches.

Concerning MS, the results of our study indicate significant differences between player positions in the

1st half and 2nd half. The FBs, WGs, and FWs showed higher speeds compared to the CDs and MDs. The trend continued in the 2nd half, with the FBs and FWs maintaining higher speeds. Statistical significance was observed across all intervals, the highlighting position-specific physical demands in soccer. This observation aligns with previous findings [28, 29], emphasising that FWs and FBs tend to reach higher speeds due to the fundamental importance of speed and attacking prowess in their role. In contrast, MDs often operate between opposition lines, engaging in shorter-duration efforts. This playing style typically limits their capacity to achieve high speeds during matches.

Due to the applicability of this information to training situations, some strategies have been explored to prepare players for MIP. For example, small-sided games (SSG) are one of the strategies widely used in training contexts [14, 25, 30], and some studies described that minor SSG situations promote more Acc and Dec actions, while situations with greater space and a number of players promote an increase in TD and HSR [14, 30]. However, SSG strategies cannot fully replicate the demands of HSR and competition sprints, so they should be complemented with other training strategies [14].

The second aim of this study was to explore changes in locomotor activity between the first and second halves of soccer matches, focusing on variations across distinct MIPs. The results show significant differences between the 1st and 2nd halves for TD and Dec during the 3- and 5-min MIP. HSR and MS also differed significantly between halves, but only in the 5-min period. No significant differences were found for Acc between halves across any period, indicating consistent performance in this variable throughout the game. Overall, our results are consistent with findings from previous literature [31, 32]. This suggests the potential onset of progressive fatigue during these scenarios. However, during the 1-min time window, no significant differences were observed in TD, which implies that players can consistently sustain their intensity over this shorter duration. Secondly, when examining HSR, no significant differences between the 1st and 2nd halves of the matches were found, except for the 5-min time window, with a very small effect. This corroborates, in part, the results presented by Torreño et al. [32]. Indeed, the ability to perform HSR is well-known as a critical attribute for soccer performance and may have a decisive impact on match outcomes [33, 34]. Third, the results of our study indicate that there are no significant differences in Acc between the first and second halves of the game when looking at 1- and 3-min durations, but there is a significant difference in the 5-min duration. For Dec, there is no significant difference in the 1-min duration, but significant differences are observed in both 3- and 5-min durations, which are partially consistent with previous studies [32, 35]. These findings suggest that players' movements in terms of both Acc and Dec tend to differentiate more as the duration increases, with more pronounced changes occurring in the second half of the game, particularly over longer periods. Finally, our study identified significant differences in MS between the first and second halves of the game during the 1-min and 5-min MIP, but not during the 3-min period. This pattern may reflect the effects of fatigue, energy management strategies, and tactical decisions on player performance as the game progresses. These findings are partially corroborated by other studies that analysed match performance data from elite soccer matches, which focused on high-intensity running and sprinting efforts [36, 37] and have demonstrated that players exhibit significantly higher intensity efforts in the first half [38].

Some limitations should be recognised in the present study, particularly the small number of participating soccer players. While 298 observations provide a robust set of data points, these come from only 20 different individuals. This sample size may not fully represent the variability and full range of performance characteristics found in the broader population of soccer players. The data may be influenced by individual player attributes or team-specific tactics that are not generalisable. Additionally, the study's cross-sectional nature precludes observation of changes over time, limiting insight into how these locomotor variables might evolve across a season or players' careers. Future research could benefit from a longitudinal design and a larger pool of participants to enhance the generalisability of the findings. In addition, there are some factors of variability between matches that may have an influence on the results, such as the location of the match and the match outcome [39], the variation in the score [40], the tactical formation [41, 42] and the change of positions of the players during the games, which were not controlled in the present study. In addition, GPS devices are also a criterion that may have an influence, as distinct equipment and brands have different frequencies, data processing algorithms and thresholds for speed zones. Despite these limitations, we consider that the results provide important insights and practical implications for soccer coaches and their staff, such as designing tailored training programs according to sectorial position to enhance the strengths and address the weaknesses highlighted in each case.

Beyond this, these data may contribute to selecting tactical strategies that capitalise on the unique attributes of players in different positions. In particular, FWs', FBs' and WGs' speed and acceleration can be leveraged for quick counterattacks, while MDs' endurance can be used to maintain ball possession and control the game's tempo. On the other hand, understanding the differences in players' performance over the course of a match is critical to support substitutions and overall game management. Coaches can make timely substitutions to maintain the team's overall performance level, especially for positions where physical attributes may decline more rapidly. Additionally, the knowledge regarding players' profiles according to sectorial position characteristics can support clubs and teams during the players' recruitment process by looking for individuals with specific physical attributes required for their desired playing style and position. Finally, these results bring important insights into injury prevention and players' long-term development. Coaches and their staff can implement injury-prevention strategies tailored to the specific needs of each sectorial position and design specific training programs during players' long-term development process to prepare them for future sectorial position demands.

Conclusions

This study has described clear patterns in locomotor activities within a soccer match, indicating distinct physical demands that vary not only by position but also as the match progresses. In the second half, players, particularly MDs and FWs, are required to cover greater distances and execute more deceleration movements, likely due to strategic shifts or decreased opposition intensity. Notably, while CDs tend to conserve their high-speed running efforts as the game advances, wingers sustain or even increase their high-tempo contributions. The trend in acceleration activities suggests an adaptation in the gameplay approach, remaining relatively stable across positions but showing a slight increase in demand during the later stages of the match. Maximum speed metrics reaffirm the ability of players to maintain peak velocities, challenging the notion of significant performance drop-offs in later halves. Collectively, these insights highlight the importance of position-specific training regimens and adaptive in-game strategies to optimise team performance and player endurance across the full duration of a match. This study supports the implementation of position-specific training to enhance endurance for WGs, address potential fatigue in defenders, boost MDs' fitness for distance coverage, and improve FWs' explosive power. Adapting the training to these roles can optimise player performance and strategic in-game management.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Faculty of Human Kinetics Ethics Committee (approval No.: CEIFMH N° 34/2021).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

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