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Section III – Sports and Physical Activity

Intra-Player Overlaps and Inter-Player Synchronisation of the Most Demanding Passages across Different Time Windows during Professional Soccer Matches

by
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This study investigated whether professional soccer players exhibit intra-player overlaps and inter-player synchronisation during the most demanding passages (MDPs) across 1-, 3- and 5-min windows and examined the effects of contextual variables. A total of 35,415 individual MDP observations from Spanish LaLiga were analysed during the 2022–2023 season. Data were obtained via a 25-Hz computerised multi-camera player tracking system. The total distance covered was used to identify MDPs via the rolling-average method. Statistical analyses assessed intra-player overlaps (players' MDPs performed across the time windows) and inter-player synchronisation (simultaneous MDP occurrences among teammates). Contextual variables included: the match location (home and away) and the team and the opponent ranking (Europe, Upper-Middle, Lower-Middle and Relegation). Intra-player overlapping predominantly occurred in longer windows (3- and 5-min), with a large effect size. Inter-player synchronisation involved two or three players (in 1-min windows). In 42% of cases, players' MDPs (MDP1) occurred without simultaneous involvement of teammates. Contextual factors had a negligible impact on intra-player overlaps and only minor effects on distance covered (mainly according to the opponents' level) and inter-player synchronisation, particularly for some team-ranking comparisons for 1- and 3-min time windows. These results suggest that players align MDPs both individually and collectively. Practical applications include implementing physical conditioning drills that replicate simultaneous demands across multiple time scales and coordinate MDPs among players.

***Keywords**: worst-case scenarios; football; time-motion; interaction; situational variables*

Introduction

The most demanding passages (MDPs) represent occurrences of peak-intensity periods of activity during soccer match-play. These are typically identified using a rolling-average method over 1- to 10-min time windows to capture the maximal physical loads performed by players (Rico-González et al., 2022). The duration of the selected time window follows a power-law relationship with the analysed variable; that is, as the selected windows increase in duration (1-, 3-, 5-, or 10-min), the observed values progressively decrease (Delaney et al., 2018b). From a conceptual perspective, understanding MDPs is crucial to avoid underestimating physical demands especially during intense match-play periods (Delaney et al., 2018a), which can occur when exclusively using average demands or a fixed set of sub-periods (e.g., 5-min non-rolling intervals) (Fereday et al., 2020). To calculate MDPs, a moving rolling-average filter is applied to kinematic and mechanical metrics such as high-speed running,

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sprinting, accelerations, and decelerations, thereby pinpointing when these variables peak (Oliva-Lozano et al., 2021b). From a practical point of view, MDPs are useful to help determine the peak demands of match-play and verify whether training prescription (Martín-García et al., 2019; Savolainen et al., 2025) replicates competition demands to help optimise physical performance and minimise injury risk (Castellano et al., 2020).

Although MDPs have proven useful as a single indicator of peak activity, recent research has identified some limitations. For example, Oliva-Lozano et al. (2021a) highlighted the need to analyse not only the most demanding episode, but also the second and third peak effort passages, as their volume and intensity may be similar to the MDP. Mandorino and Lacome (2024) extended that work by assessing the frequency with which players reached thresholds of 80% and 90% of the MDP in terms of total distance covered and high-speed activity. Recent research by Baptista et al. (2024) in female soccer showed that 40% of the total distance performed in a 60-s MDP was accumulated in a 15-s period, although output did not have to coincide in the first 15 s of the MDP. This proportion of the total distance covered increased by approximately 20% every 15 s (60% in 30 s, 80% of the total distance covered in 45 s). However, for high-speed variables (e.g., >20 $km \cdot h^{-1}$), up to 90% of the total distance covered can be accumulated in just 15 s. This work reveals an unexplored area: whether MDP scenarios overlap within individual players (intra-player) across different temporal windows during matches. Indeed, depicting how physical demand peaks are distributed and combined in match-play could have direct implications for training prescriptions to help optimise physical performance.

It is noteworthy that despite significant decreases in distance covered and high-speed efforts immediately after the MDP, players are able to maintain technical-tactical performance (Fang et al., 2025). The concept that interpersonal relationships among soccer players correspond to a superorganism is well-established (Duarte et al., 2012). Collective behaviour emerges from the coupling of players with the system (team vs. opposing team in a given game situation). Teams work tactically as a whole, and synchrony between players is key to this joint functioning (Araújo and Davids, 2016). However, physical demands in competition are often analysed at the individual level (Lago-Peñas et al., 2010), or at a team level as a result of the sum of the individualities (Errekagorri et al., 2024), even in the dual approach recently proposed to describe the worst-case scenarios (Erkizia et al., 2026), which combines an individual, player-level perspective with a collective one built as the sum of those individualities. This approach has also been used to describe the demands of MDPs (Martín-García et al., 2018), almost always from a reductionist approach by focusing on individual and decontextualised activity during intensified periods (Carling et al., 2019). It seems, therefore, that coordination between teammates and sharing physical efforts could play an important role in a team sport such as soccer (Parlebas, 2005). To our knowledge, no previous study has investigated whether players' MDPs coincide over time and research is merited to explore how an individual's output unfolds alongside that of their teammates, generating a collective synchronous response.

Several studies have examined how contextual variables affect MDPs. These included the match outcome (Fereday et al., 2020; Oliva-Lozano et al., 2021b), the team formation (Calder and Gabbett, 2022), ball-in-play time and possession (Riboli et al., 2021), the match period (Casamichana et al., 2019; Castellano et al., 2020; Oliva-Lozano et al., 2023), the length of the microcycle (Bortnik et al., 2024; Oliva-Lozano et al., 2022), and the match congestion (Bortnik et al., 2024; Castellano et al., 2020). It was found, for example, that the match location might not significantly influence the MDP (Oliva-Lozano et al., 2020), nor did the match result (Fereday et al., 2020), at least in shorter time windows (e.g., 1- and 3-min), but this could be the case in longer ones (e.g., >5 min). Broadly, MDPs appear relatively stable across matches and are largely unaffected by contextual variables. Novak et al. (2021), for instance, reported an intra-individual coefficient of variation of 4.6–8.2% for total distance in the peak 3-min periods of matches. However, this evidence refers to the magnitude of individual MDP output, not to how these passages are distributed over time within and between players. Given that teams' physical performance and collective behaviour vary according to contextual factors such as the match location and the team's performance level (Castellano et al., 2011; Errekagorri et al., 2024;

Lago-Peñas et al., 2010), the timing and coordination of MDPs could be sensitive to the context even if their magnitude is not. Further research is needed to determine to what extent contextual variables may influence MDP output in the aforementioned analyses (overlaps and synchronisation), which are the focus of the present work.

Accordingly, this study had three aims: 1) to analyse whether the individual players' MDP coincided across three time windows (1-, 3-, and 5-min) (intra-player overlaps); 2) to determine in how many players of the same team (inter-player synchronisation) the MDP was synchronised throughout the match, again considering three different time windows (1-, 3-, and 5-min); and, 3) to describe the effects of contextual variables on intra-player overlaps and inter-player synchronisation. The initial hypotheses were that, on one hand, individual players' MDPs would mostly overlap across time windows, and, on the other, MDP time windows would be synchronised between teammates most of the time, while total distance covered, intra-player overlaps, and inter-player synchronisation would be influenced by contextual factors (the match location and the performance level of the teams and their opponents).

Methods

Participants

This cohort included 20 professional male soccer teams that competed in the first division of Spanish professional soccer (LaLiga) during the 2022–2023 season. The dataset encompassed 758 team observations (out of 760 possible observations) in 380 official matches. This yielded a total of 35,415 MDPs of players across the three time windows (1-, 3- and 5-min). According to Lakens (2022), one valid approach to sample size justification is to collect data from almost the entire population, provided that the population is finite and measuring nearly every unit is feasible. In such cases, traditional power analyses are unnecessary, since there is no sampling from a larger population—the current dataset essentially represented the entire cohort.

The dataset utilised in this investigation was provided by LaLiga, which authorised analysis and the dissemination of results for scientific purposes. In strict adherence to the ethical guidelines outlined by LaLiga, this investigation does not contain any information that could lead to the identification of individual soccer players. Furthermore, all procedures and protocols employed in this study were conducted in accordance with the principles outlined in the Declaration of Helsinki. The Ethics Committee (CEISH) of the University of the Basque Country, Vitoria-Gasteiz, Spain, also granted institutional approval for the study (approval code: M10-2024-124; approval date: 21 May 2024).

Most Demanding Passages (MDPs)

To derive data for the MDP, three typical time windows were used (Rico-González et al., 2022): 1-, 3-, and 5-min (MDP1, MDP3 and MDP5, respectively). A rolling-average technique was employed for this purpose. The distance covered variable was selected to calculate the MDP of each player during the match across the three time windows. An intra-player overlap or inter-player synchronisation was defined as any temporal overlap of at least one second between two time windows. An example for a team in a match is shown in Figure 1.

Contextual Variables

Two contextual variables were considered: the match location (home and away matches) and the level of teams and their opponents. For the latter, teams were divided into four groups according to their final league ranking (Errekagorri et al., 2024): Europe (from 1st to 6th), Upper-Middle (from 7th to 11th), Lower-Middle (from 12th to 17th) and Relegation (from 18th to 20th).

Procedure

External load data during official matches were obtained using the computerised multi-camera tracking system TRACAB® (ChyronHego, New York, USA), operating at a sampling frequency of 25 Hz. The validity and reliability of this system had been previously proven for determining the positions and physical performance of players (Linke et al., 2020). Data were subsequently processed using the Mediacoach software (LaLiga, Madrid, Spain). The reports generated by Mediacoach were exported into an Excel file (Microsoft Corporation, Washington, USA) to configure a matrix for analysis.

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Statistical Analysis

To calculate the number of intra-player overlaps and the inter-player synchronisation in the MDP1, MDP3 and MDP5, statistical software R (R Core Team, 2024) for Windows was used. Descriptive statistics were presented using mean, standard deviation, median and inter quartile range (IQR) values.

A linear mixed model was fitted with total distance covered as the dependent variable in the three time windows (MDP1, MDP3 and MDP5) to analyse differences in the players' performance. The match location and the performance level of the teams and their opponents were considered as fixed effects, while player ID was considered as a random effect (random intercept; n = 584 players). The model was estimated using restricted maximum likelihood (REML), with Satterthwaite's approximation for the degrees of freedom. Significant results in the fixed effects on the total distance covered variable were analysed using post hoc pairwise comparison tests with Bonferroni correction to assess differences between the levels of the fixed effects.

After testing for normality (the Shapiro-Wilk test) and equality of variance (the Levene's test), differences between groups for both the teams and their rivals' level (for inter-player synchronisation for each of the three time windows) were determined using the non-parametric Kruskal-Wallis test, as the data distribution did not meet the normality criterion. Significant results were analysed using the post hoc Dwass-Steel-Critchlow-Fligner test. The effect size (ES) for this analysis was calculated using Epsilon-squared (ε^2). An Epsilon-squared of $\varepsilon^2 < 0.01$ was considered a very small ES; $\varepsilon^2 = 0.01–0.05$ was considered a small ES; $\varepsilon^2 = 0.06–0.13$ was considered a moderate ES; and $\varepsilon^2 \geq 0.14$ was considered a large ES (Cohen, 1988). Potential differences between home and away performance (for inter-player synchronisation for each of the three time windows) were determined using the non-parametric Mann-Whitney U test, as the data distribution did not meet the normality criterion. The ES for this analysis was calculated using the rank-biserial correlation coefficient (r_b). A rank-biserial correlation coefficient ES of $r_b < 0.10$ was considered a very small ES; $r_b = 0.10–0.29$ was considered a small ES; $r_b = 0.30–0.49$ was considered a moderate ES; and $r_b \geq 0.50$ was considered a large ES (Cohen, 1988).

The level of significance was set at $p < 0.05$. The statistical analysis (i.e., linear mixed model, non-parametric Kruskal-Wallis test, and non-parametric Mann-Whitney U test) was conducted using the statistical software Jamovi 2.6.2 (The jamovi project, 2024, https://www.jamovi.org).

Results

Mean and standard deviation (±*SD*) for distance covered across all players in MDPs were: MDP1 = 197.1 ± 30.1 m·min^{-1}, MDP3 = 152.3 ± 24.6 m·min^{-1}, and MDP5 = 139.7 ± 23.5 m·min^{-1}. Figure 1 presents an example of players' performances in a match. Both overlaps (intra-player) and synchronisation (inter-player) are displayed.

Figure 2 plots the distribution of the frequency of occurrence of intra-player overlaps. The average number of players with overlapping efforts per match was 4.7 (*SD* = 1.9; median = 5; IQR = 3) for MDP1, MDP3, and MDP5; 1.9 (*SD* = 1.5; median = 2; IQR = 2) for MDP1 and MDP3, 1.6 (*SD* = 1.3; median = 1; IQR = 1) for MDP1 and MDP5, and 4.8 (*SD* = 2.0; median = 5; IQR = 3) for MDP3 and MDP5. The mean values for the number of players per match when no instances of players' overlaps occurred between the time windows equalled 2.6 (*SD* = 1.6; median = 2; IQR = 3). The intra-player overlaps showed a significant large effect size for MDPs ($p < 0.001$; $\varepsilon 2 = 0.41$). Both the overlap of the three time windows (1-, 3- and 5-min) and the longest duration passages (3- and 5-min) were the periods with the highest occurrences during matches, with significant differences ($p < 0.001$) observed for the overlaps of 1- and 3-min, 1- and 5-min and none (i.e., when there was no overlap). Furthermore, the overlap values for 1- and 3-min time windows were significantly higher than those for 1- and 5-min ($p = 0.003$), and none was significantly higher than those for 1- and 3-min ($p < 0.001$) and 1- and 5-min ($p < 0.001$) time windows. No significant differences were observed between contextual factors (i.e., the match location and the level of the teams and their opponents).

Table 1 reports the distribution of the frequency of occurrence (in %) of inter-player synchronisation. Individual MDPs (i.e., not synchronised with any teammate) were the most frequent category in the 1-min time window

(≈42%), but their proportion decreased markedly in the 3- (≈21%) and 5-min (≈13%) time windows. However, in all three time windows, in addition to individual MDP overlaps, there was synchronisation between players, specifically ranging from two to 10 players, and in 3- and 5-min time windows, up to 11 players. Regarding MDP synchronisation, doubles and triples were the most frequent synchronisation categories in the three time windows, although together they accounted for less than half of all MDPs (40.0%, 41.1% and 34.8% for MDP1, MDP3 and MDP5, respectively): in the 1-min time window 24.5% were doubles and 15.5% triples; in the 3-min time window 23.1% were doubles and 18.0% triples, and in the 5-min time window 17.0% were doubles and 17.8% triples.

When comparing inter-player synchronisation across different contextual variables (i.e., the match location and the level of the teams and their opponents) significant differences occurred in the synchronisation frequency of six players for the team level factor for MDP1 ($p = 0.049$; $\varepsilon 2 = 0.01$, small) and MDP3 ($p < 0.001$; $\varepsilon 2 = 0.02$, small). Regarding MDP1, Lower-Middle teams showed a higher number of players simultaneously performing a MDP than Upper-Middle teams ($p = 0.030$). Regarding MDP3, Relegation teams showed more inter-player synchronisation than Europe ($p < 0.001$), Upper-Middle ($p = 0.026$) and Lower-Middle ($p = 0.010$) teams. Significant differences were also observed for MDP3 ($p = 0.036$; $\varepsilon 2 = 0.01$, small) for the synchronisation between two players according to the opponents' level. The Relegation group reported a higher number of players simultaneously performing a MDP than the Lower-Middle group ($p = 0.045$). No differences were found for the match location contextual variable.

Table 2 reports the descriptive values (e.g., mean and standard deviation) for the total distance covered by the players in the three time windows of the MDP in relation to contextual variables. Data are presented as relative distance covered per min ($m \cdot min^{-1}$). Significant differences were found in total distance covered for the three time windows considering the contextual variables. Regarding MDP1, significant differences were found in the level of the rivals, where players of the Europe group showed higher values than those of Upper-Middle (difference: 1.80; $p < 0.001$), Lower-Middle (difference: 1.01; $p = 0.030$) and Relegation (difference: 1.54; $p = 0.003$) groups. In this time window significant differences were also observed in the match location contextual variable. Players showed higher values when they played at home compared to when playing away (difference: 0.81; $p = 0.004$). Considering MDP3, significant differences were also found according to the performance level of the rivals. Players in Europe group teams showed higher values than Upper-Middle (difference: 1.23; $p < 0.001$), Lower-Middle (difference: 0.76; $p = 0.015$) and Relegation (difference: 2.45; $p < 0.001$) groups' players. In addition, players in the Relegation group teams also showed lower values than players in the Upper-Middle (difference: −1.22; $p < 0.001$) and Lower-Middle (difference: –1.69; $p < 0.001$) groups. Finally, in MDP5, significant differences were also observed according to the performance level of the rivals: players in the Europe group showed higher values than those in the Upper-Middle (difference: 1.61; $p < 0.001$), Lower-Middle (difference: 1.22; $p < 0.001$) and Relegation (difference: 2.86; $p < 0.001$) groups. In this case, players in the Relegation group also showed lower values than players of the Upper-Middle (difference: −1.25; $p < 0.001$) and Lower-Middle (difference: −1.64; $p < 0.001$) groups.

Discussion

This study had three main aims: 1) to examine whether MDP (total distance covered) across three time windows (1-, 3-, and 5-min) occurred concurrently within individual players (intra-player overlaps); 2) to evaluate the extent to which multiple teammates simultaneously performed their MDP during a match within the same time windows (inter-player synchronisation); and, 3) to describe the effects of contextual variables on intra-player overlaps and inter-player synchronisation. To the authors' knowledge, this is the first paper to address these research questions. Main findings were as follows: 1) players' MDP occurrences tended to overlap all three windows (MDP1, MDP3 and MDP5) and the two longest duration windows (MDP3 and MDP5); 2) in most cases (from ≈58% to ≈88%), MDPs in the temporal windows were synchronised among multiple players on the same team; and 3) contextual variables (i.e., the match location and the level of the teams and their opponents) did not

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affect intra-player MDP overlaps during temporal windows, and had only a minimal effect on inter-player synchronisation.

Table 1. Distribution of the occurrences (in % total and accumulated) of inter-player synchronisation within the 1-, 3-, and 5-min time windows of the MDP.

Number of players synchronised	MDP1	% reverse accumulated	MDP3	% reverse Accumulated	MDP5	% reverse accumulated
1 player (none)	41.6	100	20.7	100	12.7	100
2 players	24.5	58	23.1	79	17.0	88
3 players	15.5	34	18.0	56	17.8	71
4 players	8.7	18	14.5	38	15.3	53
5 players	5.7	10	8.8	24	11.7	37
6 players	2.1	4	7.2	15	8.9	26
7 players	1.4	2	3.6	8	6.7	17
8 players	0.1	0	2.3	4	4.5	10
9 players	0.1	0	1.2	2	2.9	6
10 players	0.2	0	0.5	1	2.2	3
11 players	0	0	0.1	0	0.5	1

MDP1, MDP3 and MDP5 are most demanding passages of 1, 3 and 5 min, respectively. The accumulated percentage represents a reverse cumulative distribution, showing the proportion of synchronisation events that involved at least a given number of players or more. Percentages refer to individual player's MDPs (n = 11,805 per time window). Percentages may not sum to 100% due to rounding

Table 2. Means and standard deviations (±*SD*) of the total distance covered (m·min^{-1}) by the players in the three time windows of the MDP1, MDP3 and MDP5 in relation to the contextual variables.

Match location	League ranking	Europe	Upper-Middle	Lower-Middle	Relegation
		MDP1			
Home	Europe	199.7 (±30.1)	195.6 (±30.3)	197.2 (±29.5)	197.1 (±29.9)
	Upper-Middle	198.8 (±28.3)	197.1 (±30.0)	197.4 (±28.9)	197.3 (±29.5)
	Lower-Middle	198.2 (±30.7)	196.5 (±29.1)	197.7 (±30.8)	197.2 (±31.6)
	Relegation	199.5 (±31.2)	198.6 (±28.3)	197.1 (±30.6)	194.8 (±31.1)
Away	Europe	198.1 (±31.8)	195.1 (±28.9)	196.6 (±30.7)	197.5 (±31.2)
	Upper-Middle	196.2 (±29.8)	195.3 (±28.0)	196.0 (±30.9)	195.3 (±32.4)
	Lower-Middle	197.6 (±29.8)	196.2 (±28.5)	198.3 (±31.1)	195.7 (±31.2)
	Relegation	195.9 (±30.5)	198.0 (±31.1)	197.3 (±30.5)	194.7 (±29.5)
		MDP3			
Home	Europe	153.0 (±24.4)	151.4 (±25.1)	152.3 (±23.9)	151.2 (±25.2)
	Upper-Middle	153.4 (±24.0)	151.6 (±24.5)	153.9 (±24.0)	151.2 (±23.1)
	Lower-Middle	153.4 (±26.2)	151.6 (±24.4)	152.1 (±24.3)	150.7 (±26.4)
	Relegation	153.4 (±24.8)	153.2 (±22.5)	150.5 (±24.5)	150.4 (±23.8)
Away	Europe	152.7 (±25.6)	151.9 (±24.1)	152.7 (±24.6)	151.7 (±24.6)
	Upper-Middle	153.1 (±24.0)	151.5 (±23.7)	152.0 (±24.7)	150.0 (±26.7)
	Lower-Middle	153.8 (±25.2)	152.6 (±24.0)	153.1 (±25.3)	150.1 (±26.0)
	Relegation	150.6 (±24.7)	152.3 (±24.4)	152.5 (±24.7)	150.3 (±23.4)
		MDP5			
Home	Europe	140.4 (±23.5)	139.4 (±24.1)	139.9 (±22.9)	139.0 (±23.5)
	Upper-Middle	141.1 (±23.1)	138.0 (±23.2)	141.1 (±22.5)	138.9 (±22.6)
	Lower-Middle	141.4 (±25.1)	138.9 (±22.9)	139.3 (±23.7)	137.5 (±24.9)
	Relegation	141.0 (±23.0)	139.8 (±21.4)	138.4 (±22.9)	138.0 (±22.9)
Away	Europe	140.4 (±24.1)	140.0 (±22.6)	140.2 (±23.3)	139.2 (±23.1)
	Upper-Middle	141.3 (±23.3)	139.0 (±22.8)	139.4 (±23.3)	136.0 (±26.4)
	Lower-Middle	141.5 (±23.9)	139.6 (±23.6)	140.1 (±23.9)	137.7 (±24.9)
	Relegation	138.1 (±23.1)	139.7 (±22.9)	138.9 (±22.7)	139.1 (±22.7)

MDP1, MDP3 and MDP5 are most demanding passages of 1, 3 and 5 min, respectively

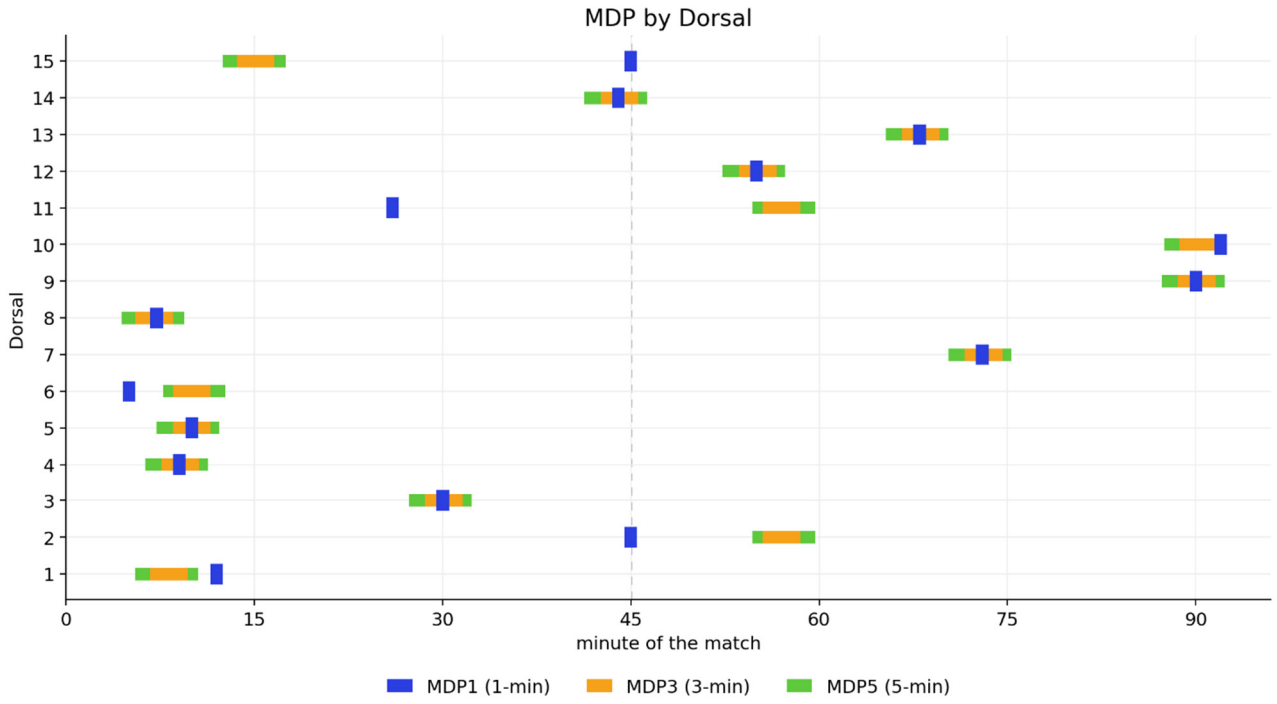


Figure 1. Example of the MDP in the three time windows of the players in a match.
blue = MDP1; orange = MDP3; green = MDP5, type 1-, 3- and 5-min periods

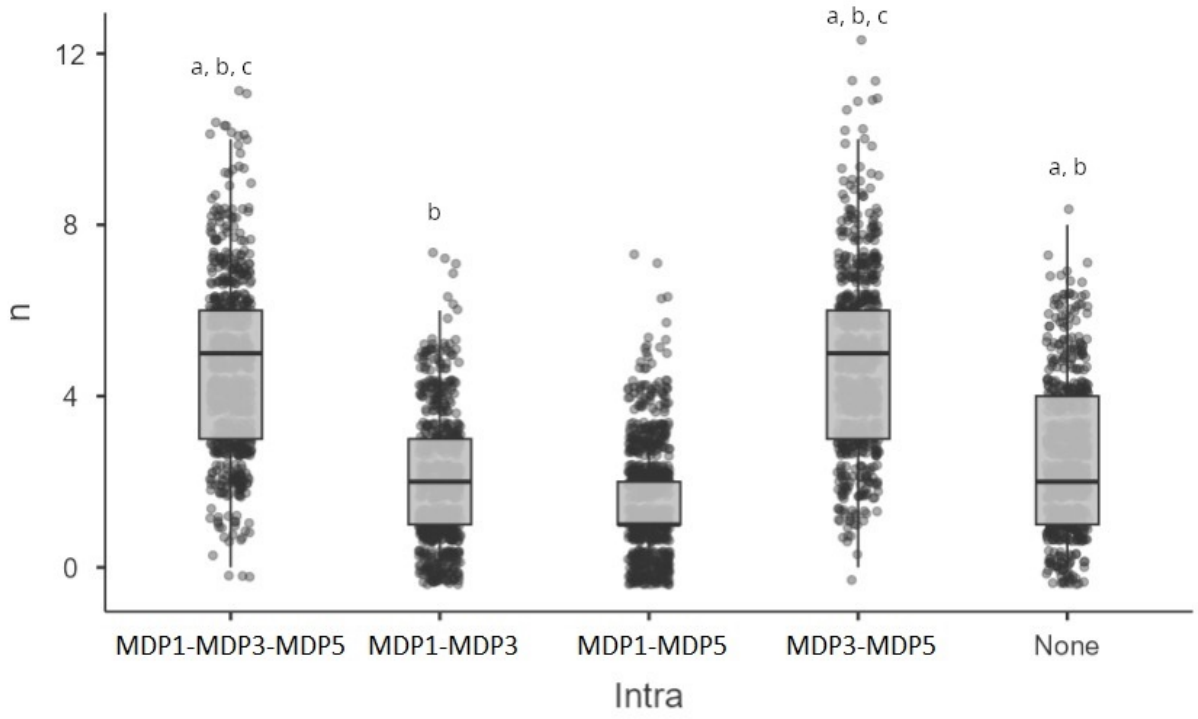


Figure 2. Boxplot displaying median values, interquartile ranges, and outliers of the frequency distribution of intra-player overlap occurrences within the 1-, 3-, and 5-min time windows of the MDPs.
a > 1- and 3-min, b > 1- and 5-min and c > none for a significance level of p < 0.05

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Intra-Player Overlaps

The intra-player analysis confirmed our initial hypothesis that individual players' MDPs generally overlapped across temporal windows. Indeed, the MDP tended to overlap all three time windows (1-, 3- and 5-min) and the two longest duration windows (3- and 5-min) specifically with significant differences compared with the other windows (1- and 3-min, 1 and 5-min, and none). The overlapping observed in these longer duration scenarios (MDP3 and MDP5) may be explained by sustained periods of play during matches, where ball-in-play time is significant, resulting in continuous efforts during which locomotor distance accumulates, thereby increasing the likelihood that the MDP coincides temporally with those observed in shorter time windows (Riboli et al., 2021). In addition, prolonged phases of continuous play, such as long transitions or intense offensive sequences, can generate accumulation of external loads that manifest themselves simultaneously over different time scales. However, tactical information was not included to support these theories and merits inclusion in future studies. Nevertheless, an integrated approach to preparing players for these scenarios, where physical conditioning includes tactical/technical and situational data (e.g., effective playing time, ball possession, player involvements on the ball, transitions etc.) is warranted.

Inter-Player Synchronisation

Our second hypothesis was also confirmed. MDPs performed across different time windows were mostly synchronised among teammates. Analysis of synchronisation between teammates showed that in most cases (≈58% for the MDP of 1 min, ≈80% for the MDP of 3 min, and ≈88% for the MDP of 5 min), players' efforts were synchronised with those of at least one teammate. The distribution indicates that doubles and triples were the most frequent forms of synchronisation in all three time windows, although together they accounted for less than half of all MDPs (≈35–41%). Notably, as time window duration increased, the number of synchronised players also increased. For example, more than 50% of the synchrony comprised three or more players in MDP3, while this number rose to four or more synchronised players in the 5-min time window (MDP5).

However, approximately 42% of the 1-min MDP occurred as individual efforts. This proportion should not be interpreted as contradicting the soccer's collective nature. Rather, these individual MDPs likely represent: (1) position-specific demands that are temporally isolated (e.g., isolated pressing runs, recovery sprints), (2) staggered activity responses to collective tactical actions where teammates reach their MDP at slightly different times, and (3) rapid adaptive reactions to unpredictable game situations that require individual responses, not allowing collective synchronisation (Delaney et al., 2018a).

As recently described (Errekagorri et al., 2024; González-Rodenas et al., 2024), teams in the Spanish LaLiga increasingly propose more collective approaches to solve offensive phases (e.g., more passes). This technical-tactical dimension is accompanied by a particular use of social space (Errekagorri et al., 2024), with higher values for some collective behaviours (e.g., width, length and surface area), thus it makes sense that any player in the same line (i.e., players in the same sector of the pitch, the midfield unit for example) or players sharing a corridor (e.g., wingers on the same wing) participate collectively during emerging game situations.

The increase in synchronisation with longer time windows (88% for 5-min MDPs) may reflect sustained tactical scenarios requiring coordinated effort: organised build-up phases involving multiple players in ball circulation, collective pressing sequences where entire units advance together, or prolonged defensive blocks where the team compresses space cohesively. In contrast, shorter 1-min MDPs may capture tactically isolated events: individual duels, isolated pressing triggers, or emergency defensive recoveries. In the defensive phase, as periods become more demanding and to avoid responding individually, players must also participate collectively (e.g., fast transitions to generate a low block or organised collective pressure in the opponent's half), where several players (e.g., between two and five) execute high locomotor efforts simultaneously to achieve the tactical goal of regaining possession (Gonçalves et al., 2018).

Contextual Variables

Our hypothesis regarding the influence of contextual variables on MDPs was partially

confirmed. No significant differences were observed in MDPs based on contextual variables (i.e., the match location, the level of the teams and their opponents) related to intra-player overlapping. Similarly, the match location did not affect inter-player synchronisation in any time window. The team level had minimal influence: in MDP1, Lower-Middle teams showed more synchronised players than Upper-Middle teams, while in MDP3, the Relegation group showed higher values than the other groups. In addition, the opponents' performance level only affected the synchronisation between two players in MDP3, which was more frequent when facing Relegation opponents than Lower-Middle opponents. These results could be explained by the fact that lower-ranked teams may need to rely more on collective play to physically compensate for the superior individual quality of players in higher-ranked teams (Castellano et al., 2011). The opponent's level was the only contextual factor affecting total distance covered per min across all time windows, whereas the match location had an effect only in MDP1. Although previous research reports higher physical output in home versus away teams (Lago-Peñas et al., 2010; Oliva-Lozano et al., 2021c), here, it appears that MDP distances covered and occurrences were very little influenced by the match location. In contrast, MDPs showed a higher distance demand when facing higher-ranked opponents (i.e., Europe group). Previous studies (Castellano et al., 2011; Lago-Peñas et al., 2010) had typically reported that teams, when facing higher-level opponents, ran more. This consistency regarding the present players' MDPs underlines that teams must not neglect this component in their training to prepare for all contexts. As recently proposed (Mandorino and Lacome, 2024), perhaps considering time spent above particular thresholds (>80% and >90% of the MDP for total distance and high-speed-running, respectively) could provide additional information for individualised or position-specific training prescriptions.

Limitations

This study has some limitations. Firstly, only the total distance covered was analysed. Even though it represents the most comprehensive measure of physical workload, integrating all locomotor activity regardless of intensity, additional locomotor variables (e.g., distance covered at higher velocities), or variables related to the neuromuscular dimension (e.g., accelerations and decelerations) might have resulted in different patterns of overlapping and synchronisation among players (Rico-González et al., 2022). Indeed, the MDP does not always occur concurrently for all metrics (Novak et al., 2021). Secondly, it should be emphasised that players' positions were not distinguished, nor was consideration given to whether players were starters who completed the match, were substituted, or were non-starters (Bortnik et al., 2024). Differentiation in terms of the playing position and match participation could potentially lead to specific patterns for MDPs in individual overlaps and team synchronisation. Future studies should include the roles of players. Finally, the inclusion of additional contextual variables, such as scoreline (Martín-Fuentes et al., 2021) or the tactical system used (Riboli et al., 2021), could have further enhanced the present findings.

Conclusions

This study demonstrates that players consistently experienced overlapping of their most demanding passages particularly across all three time windows, and specifically in the 3- and 5-min time windows. Moreover, these highly demanding passages were frequently synchronised among teammates, indicating coordinated collective efforts during match phases and further increased in coordination as the duration of the time window increased. Finally, contextual variables, such as the match location and the performance level of the teams, did not influence intra-player MDP overlaps and had only a minimal effect on inter-player synchronisation. These findings emphasise that MDPs are inherent to game dynamics, and largely independent of situational variables, highlighting the need for training strategies that foster both individual and coordinated team performance during most demanding passages of play.

Practical Implications

Practical implications can be related to the need to consider intra-player overlaps and inter-player synchronisation in training when designing drills to help players respond to the most demanding passages of play. It may be beneficial, where appropriate, to replicate most demanding

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passages not only through isolated time windows but by attempting to integrate multiple windows simultaneously. Similarly, although on some occasions it may be interesting to tackle tasks with very few players (Asian-Clemente et al., 2025), and considering that the longer the MDP, the more collective it becomes, designing tasks that physically engage multiple players simultaneously represents a promising strategy, as it reinforces the need for team coordination and collaboration to achieve successful task completion. For example, coaches could design a combination of drills in which groups of players perform transition games (Asian-Clemente et al., 2024), immediately followed by a longer collective phase (e.g., three minutes of positional play under fatigue in large-sided formats, such as up to 6v6 and >200 m² per player), thereby providing more opportunities to cover greater total distances and to simulate how players must alternate between individual overlaps and team-level coordination.

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