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**Section III – Sports and Physical Activity**

# The Peak Speed Dynamics of Highly Trained Soccer Players during Matches and Training Sessions

*by*
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*This study compared the peak speed dynamics of soccer players during different training sessions and competition, focusing on the speed distribution over a 20-s window. Twenty-five highly trained players were monitored with 10-Hz global navigation satellite systems across eight competitive weeks. Days were classified in relation to the match-day (MD): MD−4, MD−3, MD−2, MD−1 and MD. Raw data were used to calculate peak speed (highest speed reached), initial speed (10 s before the peak), final speed (20 s after the peak), and the nearest accelerations and decelerations. Independent mean differences were used to compare the differences between days. Higher peak speeds, but lower initial and final speeds, were achieved during the MD−2 than any other day ($p < 0.001$). Higher decelerations were registered during the MD−4 ($p < 0.001$). Except for the peak speed ($p < 0.001$), no differences were found between the MD−3 and the MD. The peak speed dynamics varied across days. While MD−2 (speed training) had the highest speed, players reached these speeds mostly from stationary positions, unlike in competition. The MD−3 and the MD showed similar peak speed dynamics, with high-speed displacements being important for preparing players for match demands. This study emphasizes the need to incorporate a leading start during sprints in the MD−2 training session to replicate peak match speed dynamics, potentially reducing the risk of hamstring injuries.*

***Keywords**: acceleration; competition; deceleration; external load; velocity*

## Introduction

Soccer players perform a multitude of repetitive actions during a match, including multiple accelerations, decelerations, and sprints (Dolci et al., 2020). Therefore, soccer players must possess a well-developed neuromuscular system, with high levels of strength, power, and the rate of force development (Loturco et al., 2018; Wisløff et al., 2004). In this regard, male senior players perform approximately 1.8 ± 0.5 accelerations and 1.8 ± 0.4 decelerations per minute, with magnitude exceeding 3 m/s², during a typical competitive match (Martin-Garcia et al., 2019). Meanwhile, when using a fixed threshold of 25.2 km/h to define a sprint, an elite European club recorded an average of 134.5 ± 103.5 m sprinted during official matches (Silva et al., 2024). This value is consistent with results from other studies that quantified sprint distances in elite soccer players, with distances ranging from 131 to 295 m (Di Salvo et al., 2010; Sæterbakken et al., 2019). High-speed displacements are gaining importance as these efforts have increased recently, despite a decline in total distance covered in major competitions (Allen et al., 2023; Lago-Peñas et al., 2023). Although these data are valuable, they provide only a partial view of what occurs during sprints in competition, as

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they do not thoroughly depict peak speeds or the patterns of acceleration and deceleration before and after achieving those peak speeds.

Recently, it was shown that peak speeds registered during competitive matches could range from 29.1 to 31.6 km/h in elite players of different positions (Silva et al., 2025). Notably, speeds recorded 10 s before and after peak speed varied between 5.1 and 9.2 km/h and 6.9 and 7.65 km/h, respectively. However, that study did not analyze the magnitude of accelerations and decelerations leading to and following the attainment of peak speeds. This is relevant, as running and acceleration are the most common situational patterns where injuries occur, especially in the hamstrings (Della Villa et al., 2023; Harper et al., 2022), which can significantly impair performance. A comprehensive analysis of sprint patterns, including acceleration and deceleration magnitude, is essential for understanding the intense muscular demands of competitive matches. While exposing players to near-maximal speeds in training enhances readiness and reduces injury risk (Gómez-Piqueras and Alcaraz, 2024), it must be carefully integrated into the overall weekly load (Silva et al., 2023a). As a result, the MD−2 is commonly recommended for this stimulus (Gómez-Piqueras and Alcaraz, 2024). Additionally, previous reports have indicated that sprint training can positively influence muscle architecture, mitigate the risk of injuries, and enhance performance (Mendiguchia et al., 2020).

Accordingly, this study aimed to compare peak speed dynamics during different training sessions and competition. Considering that practitioners increase the exposure of players to higher training demands during the middle of the week (Silva et al., 2023a), we hypothesized that, during a typical competitive microcycle, highly-trained players would achieve similar speeds, accelerations, and decelerations during midweek sessions, with specific demands for each training session, without necessarily replicating the competitive peak speed dynamics.

## Methods

### *Participants*

Twenty-five (n = 25) highly trained (professional) soccer players from a Portuguese team competing in the U23 Portuguese league, were selected to participate in this study (mean ± standard deviation [SD] for age, body height, body mass, and training experience were 19.0 ± 1.1 years, 179.3 ± 6.2 cm, 75.1 ± 6.7 kg, and 12.0 ± 1.8 years, respectively). Due to the specific demands of their position, goalkeepers were excluded from this analysis. Additionally, only players who participated in at least five activities (training sessions and/or matches) were included. This inclusion criterion excluded potential sporadic participation of players not being part of the usual squad, which is common in some academies where players are assessed for potential inclusion in the team. The playing positions were defined by the technical staff as follows: central defender (CD; n = 4), fullback (FB; n = 5), central midfielder (CM; n = 8), wide midfielder (WM; n = 5), and forward (FW; n = 3). An a priori power analysis was conducted using G*Power software (Version 3.1.9.6), which determined that 176 observations were required to achieve a power of 0.95. The number of observations recorded was 639 (CD = 115; FB = 130; CM = 189; WM = 115; FW = 90), and the number of individual observations ranged from 7 to 39. Data collection and treatment followed the Declaration of Helsinki guidelines and were approved by the Ethics Committee of the University of Maia, Maia, Portugal (protocol code: 210/2024; approval date: 28 May 2024).

### *Measures*

This study analyzed peak speeds using a similar approach to that of a previous research paper (Silva et al., 2025), applying peak speed analysis over a 20-s window. Specifically, this approach analyzes peak speed in relation to speed distribution during the 10 s before and after the peak effort, capturing the full effort—including how it begins and how it ends. Over the course of eight competitive weeks (n = 8), each including four training sessions and one match during the in-season period, highly-trained players were monitored with a 10-Hz global navigation satellite system (GNSS) (GPS, Catapult, Vector S7, Catapult Sports, Melbourne, Australia) retrieving raw data to calculate speeds (across 20 s), allowing for the calculation of accelerations and decelerations by determining the change in velocity over time. This device was certified by FIFA (Certification number: 1003407) from 31 August 2023 to 30 August 2027, and its validity and reliability have been previously demonstrated (Clavel et al., 2022;

Crang et al., 2023). Specifically, the analysis showed a mean error (± 95% confidence limits) of −0.37 (−0.50 to −0.23) for accelerations and 0.09 (−0.25 to 0.08) for decelerations, with a typical error of the estimate (± 95% confidence limits) of 0.35 (0.28 to 0.46) for accelerations and 0.43 (0.34 to 0.57) for decelerations (Crang et al., 2023). For maximum sprint speed, the standardized typical error of the estimate (± 90% confidence interval) was 0.10 (0.08 to 0.12), with an intraclass correlation (± 90% confidence interval) of 0.99 (0.98 to 1.00) (Clavel et al., 2022).

### *Design and Procedures*

The GNSS devices were secured between the upper scapulae, approximately at the T3–4 junction, and were activated 15 min before use, following the manufacturer's instructions. To minimize interunit error, each player used the same device throughout the season. The mean ± SD of the number of satellites available and the horizontal dilution of precision (HDOP) from the retrieved files were 15 ± 1 and 0.70 ± 0.07, respectively, ensuring high reliability (Malone et al., 2017). Raw data were extracted using GPS software (OpenField Console, Catapult Sports, Melbourne, Australia), which included speed (km/h) and time (ms).

From each file, peak speed was identified as the highest speed recorded, and data from the preceding and subsequent 10 s (resulting in a 20-s analysis window) were collected for analysis (201 data points). Accelerations and decelerations were calculated as the change in velocity divided by the change in time, capturing instances where speed increased (acceleration) or decreased (deceleration) without specifying the minimum effort duration (Silva et al., 2023b). Since raw data imply the absence of filters, the following filters were created to prevent potential errors or noise: first, files where the highest speed exceeded 44.45 km/h (Janjić et al., 2014) were excluded; second, accelerations exceeding 9.5 m/s$^2$ (Hernández Gómez et al., 2013) were also excluded; and lastly, files were excluded when the peak speed was below 19.8 km/h, as this threshold has been established as the minimum speed for a displacement to be classified as a sprint in male soccer players (Gualtieri et al., 2023). In addition to the peak speed of each session, four other data points were retrieved: the starting speed recorded 10 s before the peak speed (the first data point of the 20-s window), the final speed recorded 10 s after the peak speed (the last data point of the 20-s window), the nearest acceleration before the peak speed, and the nearest deceleration after the peak speed. Regarding accelerations and decelerations, an additional filter was implemented to exclude potential noise: only efforts ≥ 1 m/s$^2$ (or ≤ −1 m/s$^2$ for decelerations) were considered. For example, if the closest acceleration was 0.6 m/s$^2$, that effort was not included, and the next closest acceleration was retrieved. A visual representation of the procedure is depicted in Figure 1.

Days were classified based on their proximity to the match day (MD) using the match day minus approach. For example, MD−1 refers to the day before the match, MD−2 refers to two days before the match, and so forth. Using this approach, the data were categorized as MD−4 (n = 120 files), MD−3 (n = 130), MD−2 (n = 143), MD−1 (n = 140), and MD (n = 106). The average external load of the training sessions is presented in Figure 2. Notably, the training sessions were planned by the coaching staff as part of their regular procedure, without any intervention from the research team. The training 'periodization' was outlined according to the tactical periodization model. Briefly, MD−4 was characterized by small-sided games with a lower volume in terms of the number of sets per exercise, prioritizing intensity within the small-sided games. MD−3 was characterized by larger-scale games and game situations where the volume was higher. MD−2 was defined as a speed-focused day, emphasizing transition situations and small plays requiring rapid decision-making. Lastly, MD−1 was characterized by strategic components, such as tactical circulations and set plays. Notably, the team utilized a 4-3-3 formation.

### *Statistical Analysis*

All statistical analyses were performed using Microsoft Excel (Microsoft Corporation; Version 16.68) and Jamovi (with the ESCI package) (Jamovi, 2022; R Core Team, 2021). Means ± SD were calculated for each variable (initial speed, peak speed, final speed, acceleration, and deceleration) and organized by an overall approach, by playing position (CD, FB, CM, WM, FW), and by day (MD−4, MD−3, MD−2, MD−1, MD). Additionally, independent mean differences with 95% confidence intervals (95% CI) were

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calculated to assess potential differences in each variable between playing positions or days. Cohen's (*d*) effect sizes were categorized as follows: trivial (≤ 0.2), small (> 0.2–0.6), moderate (> 0.6–1.2), large (> 1.2–2.0), very large (> 2.0–4.0) and extremely large (> 4.0) with 95% CIs (Hopkins et al., 2009). If the CI crossed zero, the effect size was considered unclear ($p$ > 0.05) (Batterham and Hopkins, 2006).

## Results

The means ± SD for peak speed, initial speed, final speed, acceleration, and deceleration across days and playing positions are detailed in Table 1. Speed variation across the 20-s window is visualized in Figure 3, and comparisons between days using independent mean differences are shown in Table 2.

Peak speeds were significantly higher during the MD than the MD−1, the MD−4, and the MD−3, but lower than during the MD−2. Notably, the MD−2 also recorded higher peak speeds compared to the MD−4, the MD−3, and the MD−1. Further, the MD−3 exhibited higher peak speeds than the MD−4, and the MD−4 surpassed the MD−1 in terms of peak speed.

Differences in initial speeds were observed 10 s before peak speed, with the MD−2 showing significantly lower speeds than the MD−4, the MD−3, the MD−1, and the MD, while the MD−1 showed lower speeds than the MD−4. Additionally, final speeds during the MD−1 were lower than during the MD−4 and the MD−3.

Accelerations before peak speed were higher during the MD−4 compared to the MD−3, the MD−1, and the MD, with the MD−2 demonstrating higher accelerations than the MD−3, the MD−1, and the MD. In terms of deceleration after peak speed, the MD−4 registered higher magnitude than the MD−3, the MD−2, the MD−1, and the MD.

Since different playing positions were considered, the comparisons are presented in Table 3. The differences were summarized as follows: FBs (0.29 [0.04, 0.55], $p$ = 0.024) and FWs (0.40 [0.13, 0.59], $p$ = 0.004) achieved higher peak speeds than CDs (small effect sizes); and CMs performed decelerations with lower magnitude than FBs (−0.31 [−0.54, −0.09], $p$ = 0.006), WMs (0.39 [0.06, 0.53], $p$ = 0.006), and FWs (0.29 [0.04, 0.55], $p$ = 0.014) (all with small effect sizes).

**Table 1.** Means ± SD of peak speed, initial speed, final speed, acceleration and deceleration for each day, for each playing position, and overall.

| | Peak Speed | Initial Speed | Final Speed | Acceleration | Deceleration |
|---|---|---|---|---|---|
| *Days* | | | | | |
| MD−4 (*n* = 120) | 26.68 ± 2.19 | 7.21 ± 6.62 | 6.82 ± 4.41 | 5.71 ± 1.80 | 7.04 ± 2.67 |
| MD−3 (*n* = 130) | 27.57 ± 2.01 | 5.98 ± 4.55 | 6.37 ± 3.81 | 4.43 ± 1.71 | 5.62 ± 2.43 |
| MD−2 (*n* = 143) | 31.04 ± 1.61 | 0.65 ± 1.10 | 4.27 ± 1.66 | 5.70 ± 2.20 | 5.70 ± 2.06 |
| MD−1 (*n* = 140) | 24.33 ± 2.52 | 5.31 ± 4.93 | 5.47 ± 3.33 | 5.00 ± 1.96 | 5.84 ± 2.56 |
| MD (*n* = 106) | 29.33 ± 1.69 | 6.05 ± 5.47 | 6.41 ± 4.18 | 4.88 ± 1.87 | 6.01 ± 2.80 |
| *Playing position* | | | | | |
| CD (*n* = 115) | 27.07 ± 3.32 | 4.46 ± 4.89 | 5.52 ± 3.34 | 5.06 ± 2.07 | 6.03 ± 2.47 |
| FB (*n* = 130) | 28.02 ± 3.17 | 5.35 ± 5.60 | 6.23 ± 3.80 | 5.40 ± 1.84 | 6.30 ± 2.46 |
| CM (*n* = 189) | 27.73 ± 2.93 | 4.48 ± 5.06 | 5.70 ± 3.84 | 5.15 ± 2.03 | 5.54 ± 2.42 |
| WM (*n* = 115) | 27.76 ± 3.29 | 5.28 ± 5.37 | 5.95 ± 3.36 | 4.96 ± 2.12 | 6.30 ± 2.89 |
| FW (*n* = 90) | 28.35 ± 2.88 | 5.07 ± 5.96 | 5.51 ± 3.77 | 5.19 ± 1.79 | 6.25 ± 2.41 |
| *Overall* | | | | | |
| *All (n = 639)* | 27.76 ± 3.12 | 4.88 ± 5.33 | 5.79 ± 3.65 | 5.16 ± 1.98 | 6.02 ± 2.54 |

*MD−4: four days before the match-day; MD−3: three days before the match-day; MD−2: two days before the match-day; MD−1: one day before the match-day; MD: match-day. CD: Central defenders; FB: Full backs; CM: Central midfielders; WM: Wide midfielders; FW: Forwards; n = number of files*

**Table 2**. Independent mean differences [95% CI] and effect size (Cohens' *d* [95% CI]) according to the match-day (MD) for peak speed, initial speed, final speed, accelerations, and decelerations.

| | Peak Speed | Initial Speed | Final Speed | Accelerations | Decelerations |
|---|---|---|---|---|---|
| MD−4 vs. MD−3 | | | | | |
| IMD [95% CI] | 0.89 [0.37, 1.42] | −1.23 [−2.63, 0.18] | −0.45 [−1.48, 0.57] | −1.28 [−1.71, −0.84] | −1.42 [−2.05, −0.78] |
| *d* [95% CI] | 0.42 [0.17, 0.68]$^{S}$ | −0.22 [−0.47, 0.03]$^{U}$ | −0.11 [−0.36, 0.14]$^{U}$ | −0.73 [−0.99, −0.47]$^{M}$ | −0.55 [−0.81, −0.30]$^{S}$ |
| *p*-value | < 0.001 | 0.086 | 0.383 | < 0.001 | < 0.001 |
| MD−4 vs. MD−2 | | | | | |
| IMD [95% CI] | 4.36 [3.89, 4.82] | −6.56 [−7.66, −5.45] | −2.55 [−3.34, −1.77] | −0.00 [−0.50, 0.49] | −1.34 [−1.91, −0.76] |
| *d* [95% CI] | 2.29 [2.00, 2.63]$^{VL}$ | −1.44 [−1.72, −1.18]$^{L}$ | −0.79 [−1.05, −0.54]$^{M}$ | −0.00 [−0.25, 024]$^{U}$ | −0.57 [−0.82, −0.32]$^{S}$ |
| *p*-value | < 0.001 | < 0.001 | < 0.001 | 0.986 | < 0.001 |
| MD−4 vs. MD−1 | | | | | |
| IMD [95% CI] | −2.35 [−2.93, −1.77] | −1.90 [−3,31, −0.49] | −1.35 [−2.29, −0.40] | −0.70 [−1.16, −0.24] | −1.19 [−1.83, −0.55] |
| *d* [95% CI] | −0.99 [−1.25, −0.74]$^{M}$ | −0.33 [−0.58, −0.08]$^{S}$ | −0.35 [−0.60, −0.10]$^{S}$ | −0.37 [−0.62, −0.13]$^{S}$ | −0.45 [−0.71, −0.21]$^{S}$ |
| *p*-value | < 0.001 | 0.009 | 0.005 | 0.003 | < 0.001 |
| MD−4 vs. MD | | | | | |
| IMD [95% CI] | 2.65 [2.13, 3.16] | −1.16 [−2.75, 0.45] | −0.41 [−1.54, 0.72] | −0.82 [−1.31, −0.34] | −1.03 [−1.74, −0.31] |
| *d* [95% CI] | 1.34 [1.06, 1.64]$^{L}$ | −0.19 [−0.45, 0.07]$^{U}$ | −0.09 [−0.36, 0.17]$^{U}$ | −0.45 [−0.72, −0.19]$^{S}$ | −0.37 [−0.64, −0.11]$^{S}$ |
| *p*-value | < 0.001 | 0.156 | 0.479 | < 0.001 | 0.005 |
| MD−3 vs. MD−2 | | | | | |
| IMD [95% CI] | 3.47 [3.03, 3.90] | −5.33 [−6.10, −4.55] | −2.10 [−2.79, −1.41] | 1.27 [0.80, 1.74] | 0.08 [−0.46, 0.61] |
| *d* [95% CI] | 1.91 [1.63, 2.21]$^{L}$ | −1.64 [−1.93, −1.38]$^{L}$ | −0.72 [−0.98, −0.48]$^{M}$ | 0.64 [0.40, 0.89]$^{M}$ | 0.03 [−0.20, 0.27]$^{U}$ |
| *p*-value | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.775 |
| MD−3 vs. MD−1 | | | | | |
| IMD [95% CI] | −3.24 [−3.79, −2.69] | −0.67 [−1.81, 0.47] | −0.89 [−1.75, −0.04] | 0.58 [0.13, 1.02] | 0.22 [−0.38, 0.82] |
| *d* [95% CI] | −1.41 [−1.69, −1.15]$^{L}$ | −0.14 [−0.38, 0.10]$^{U}$ | −0.25 [−0.49, −0.01]$^{S}$ | 0.31 [0.07, 0.56]$^{S}$ | 0.09 [−0.15, 0.33]$^{U}$ |
| *p*-value | < 0.001 | 0.248 | 0.041 | 0.011 | 0.462 |
| MD−3 vs. MD | | | | | |
| IMD [95% CI] | 1.75 [1.27, 2.24] | 0.07 [−1.21, 1.36] | 0.05 [−0.98, 1.07] | 0.45 [−0.01, 0.91] | 0.39 [−0.28, 1.06] |
| *d* [95% CI] | 0.93 [0.67, 1.21]$^{M}$ | 0.01 [−0.24, 0.27]$^{U}$ | 0.01 [−0.25, 0.27]$^{U}$ | 0.25 [−0.00, 0.51]$^{U}$ | 0.15 [−0.11, 0.41]$^{U}$ |
| *p*-value | < 0.001 | 0.913 | 0.927 | 0.054 | 0.252 |
| MD−2 vs. MD−1 | | | | | |
| IMD [95% CI] | −6.71 [−7.20, −6.21] | 4.66 [3.83, 5.49] | 1.20 [0.59, 1.82] | −0.70 [−1.18, −0.21] | 0.15 [−0.40, 2.32] |
| *d* [95% CI] | −3.17 [−3.55, −2.84]$^{VL}$ | 1.31 [1.06, 1.57]$^{L}$ | 0.46 [0.22, 0.70]$^{S}$ | −0.33 [−0.57, −0.10]$^{S}$ | 0.06 [−0.17, 0.30]$^{U}$ |
| *p*-value | < 0.001 | < 0.001 | < 0.001 | 0.005 | 0.596 |
| MD−2 vs. MD | | | | | |
| IMD [95% CI] | −1.71 [−2.13, −1.30] | 5.40 [4.47, 6.32] | 2.14 [1.39, 2.90] | −0.82 [−1.34, −0.30] | 0.31 [−0.29, 0.92] |
| *d* [95% CI] | −1.04 [−1.32, −0.78]$^{M}$ | 1.47 [1.20, 1.77]$^{L}$ | 0.71 [0.46, 0.98]$^{M}$ | −0.39 [−0.65, −0.14]$^{S}$ | 0.13 [−0.12, 0.38]$^{U}$ |
| *p*-value | < 0.001 | < 0.001 | < 0.001 | 0.002 | 0.310 |
| MD−1 vs. MD | | | | | |
| IMD [95% CI] | 4.99 [4.44, 5.55] | 0.74 [−0.57, 2.05] | 0.94 [−0.00, 1.88] | −0.12 [−0.61, 0.36] | 0.17 [−0.51, 0.84] |
| *d* [95% CI] | 2.26 [1.96, 2.61]$^{VL}$ | 0.14 [−0.11, 0.40]$^{U}$ | 0.25 [−0.00, 0.51]$^{U}$ | −0.06 [−0.32, 0.19]$^{U}$ | 0.06 [−0.19, 0.32]$^{U}$ |
| *p*-value | < 0.001 | 0.286 | 0.051 | 0.621 | 0.628 |

*MD−4: four days before the match-day; MD−3: three days before the match-day; MD−2: two days before the match-day; MD−1: one day before the match-day; MD: match-day. CI: Confidence Interval. U: Unclear effect size, S: Small effect size; M: Moderate effect size; L: Large effect size; VL: Very Large effect size*

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**Table 3**. Independent mean differences [95% CI] and effect size (Cohens' *d* [95% CI]) according to playing positions for peak speed, initial speed, final speed, accelerations, and decelerations.

| | Peak Speed | Initial Speed | Final Speed | Accelerations | Decelerations |
|---|---|---|---|---|---|
| CD vs. FB | | | | | |
| IMD [95% CI] | 0.95 [0.13, 1.76] | 0.89 [−0.44, 2.22] | 0.71 [−0.19, 1.62] | 0.35 [−0.15, 0.84] | 0.27 [−0.36, 0.89] |
| *d* [95% CI] | 0.29 [0.04, 0.55]$^{S}$ | 0.17 [−0.08, 0.42]$^{U}$ | 0.20 [−0.05, 0.45]$^{U}$ | 0.18 [−0.07, 0.43]$^{U}$ | 0.11 [−0.14, 0.36]$^{U}$ |
| *p*-value | 0.024 | 0.189 | 0.123 | 0.168 | 0.400 |
| CD vs. CM | | | | | |
| IMD [95% CI] | 0.65 [−0.06, 1.37] | 0.02 [−1.14, 1.19] | 0.18 [−0.67, 1.03] | 0.09 [−0.39, 0.56] | −0.50 [−1.07, 0.07] |
| *d* [95% CI] | 0.21 [−0.02, 0.45]$^{U}$ | 0.00 [−0.23, 0.24]$^{U}$ | 0.05 [−0.18, 0.28]$^{U}$ | 0.04 [−0.19, 028]$^{U}$ | −0.20 [−0.44, 0.03]$^{U}$ |
| *p*-value | 0.074 | 0.968 | 0.678 | 0.721 | 0.085 |
| CD vs. WM | | | | | |
| IMD [95% CI] | 0.69 [−0.17, 1.54] | 0.82 [−0.51, 2.16] | 0.43 [−0.44, 1.30] | −0.10 [−0.65, 0.44] | 0.26 [−0.44, 0.96] |
| *d* [95% CI] | 0.21 [−0.05, 0.47]$^{U}$ | 0.16 [−0.10, 0.42]$^{U}$ | 0.13 [−0.13, 0.39]$^{U}$ | −0.05 [−0.31, 0.21]$^{U}$ | 0.10 [−0.16, 0.36]$^{U}$ |
| *p*-value | 0.117 | 0.226 | 0.336 | 0.711 | 0.460 |
| CD vs. FW | | | | | |
| IMD [95% CI] | 1.27 [0.40, 2.14] | 0.61 [−0.89, 2.10] | −0.01 [−0.99, 0.97] | 0.13 [−0.41, 0.68] | 0.22 [−0.46, 0.89] |
| *d* [95% CI] | 0.40 [0.13, 0.59]$^{S}$ | 0.11 [−0.16, 0.39]$^{U}$ | −0.00 [−0.28, 0.28]$^{U}$ | 0.07 [−0.21, 0.35]$^{U}$ | 0.09 [−0.19, 0.37]$^{U}$ |
| *p*-value | 0.004 | 0.422 | 0.987 | 0.626 | 0.532 |
| FB vs. CM | | | | | |
| IMD [95% CI] | −0.29 [−0.97, 0.39] | −0.86 [−2.05, 0.32] | −0.53 [−1.39, 0.32] | −0.26 [−0.70, 0.18] | −0.76 [−1.31, −0.22] |
| *d* [95% CI] | −0.10 [−0.32, 0.13]$^{U}$ | −0.16 [−0.39, 0.06]$^{U}$ | −0.14 [−0.36, 0.08]$^{U}$ | −0.13 [−0.36, 0.09]$^{U}$ | −0.31 [−0.54, −0.09]$^{S}$ |
| *p*-value | 0.400 | 0.152 | 0.222 | 0.245 | 0.006 |
| FB vs. WM | | | | | |
| IMD [95% CI] | −0.26 [−1.07, 0.55] | −0.07 [−1.45, 1.32] | −0.29 [−1.19, 0.62] | −0.45 [−0.95, 0.05] | −0.00 [−0.68, 0.67] |
| *d* [95% CI] | −0.08 [−0.33, 0.17]$^{U}$ | −0.01 [−0.26, 0.24]$^{U}$ | −0.08 [−0.33, 0.17]$^{U}$ | −0.23 [−0.48, 0.02]$^{U}$ | −0.00 [−0.25, 0.25]$^{U}$ |
| *p*-value | 0.531 | 0.925 | 0.534 | 0.078 | 0.991 |
| FB vs. FW | | | | | |
| IMD [95% CI] | 0.33 [−0.50, 1.15] | −0.28 [−1.83, 1.27] | −0.72 [−1.74, 0.30] | −0.21 [−0.70,0.28] | −0.05 [−0.71, 0.61] |
| *d* [95% CI] | 0.11 [−0.16, 0.38]$^{U}$ | −0.05 [−0.32, 0.22]$^{U}$ | −0.19 [−0.46, 0.08]$^{U}$ | −0.12 [−0.39, 0.15]$^{U}$ | −0.02 [−0.29, 0.25]$^{U}$ |
| *p*-value | 0.433 | 0.723 | 0.166 | 0.396 | 0.880 |
| CM vs. WM | | | | | |
| IMD [95% CI] | 0.03 [−0.68, 0.75] | 0.80 [−0.41, 2.00] | 0.25 [−0.61,1.10] | −0.19 [−0.67, 0.29] | 0.76 [0.15, 1.37] |
| *d* [95% CI] | 0.01 [−0.22, 0.24]$^{U}$ | 0.15 [−0.08, 0.39]$^{U}$ | 0.07 [−0.17, 0.30]$^{U}$ | −0.09 [−0.32, 0.14]$^{U}$ | 0.39 [0.06, 0.53]$^{S}$ |
| *p*-value | 0.930 | 0.193 | 0.571 | 0.439 | 0.014 |
| CM vs. FW | | | | | |
| IMD [95% CI] | 0.62 [−0.11, 1.35] | 0.59 [−0.77, 1.94] | −0.19 [−1.15, 0.77] | 0.05 [−0.45, 0.54] | 0.71 [0.10, 1.32] |
| *d* [95% CI] | 0.21 [−0.04, 0.47]$^{U}$ | 0.11 [−0.14, 0.36]$^{U}$ | −0.05 [−0.30, 0.20]$^{U}$ | 0.02 [−0.23, 0.28]$^{U}$ | 0.29 [0.04, 0.55]$^{S}$ |
| *p*-value | 0.098 | 0.395 | 0.700 | 0.850 | 0.022 |
| WM vs. FW | | | | | |
| IMD [95% CI] | 0.59 [−0.28, 1.45] | −0.21 [−1.78, 1.35] | −0.43 [−1.42, 0.55] | 0.24 [−0.31, 0.79] | −0.05 [−0.79, 0.70] |
| *d* [95% CI] | 0.19 [−0.09, 0.47]$^{U}$ | −0.04 [−0.32, 0.24]$^{U}$ | −0.12 [−0.40, 0.15]$^{U}$ | 0.12 [−0.16, 0.40]$^{U}$ | −0.02 [−0.30, 0.26]$^{U}$ |
| *p*-value | 0.181 | 0.788 | 0.385 | 0.398 | 0.902 |

*CD: central defenders; FB: fullbacks; CM: central midfielders; WM: wide midfielders; FW: forwards. CI: Confidence Interval. U: Unclear effect size, S: Small effect size; M: Moderate effect size; L: Large effect size; VL: Very Large effect size*

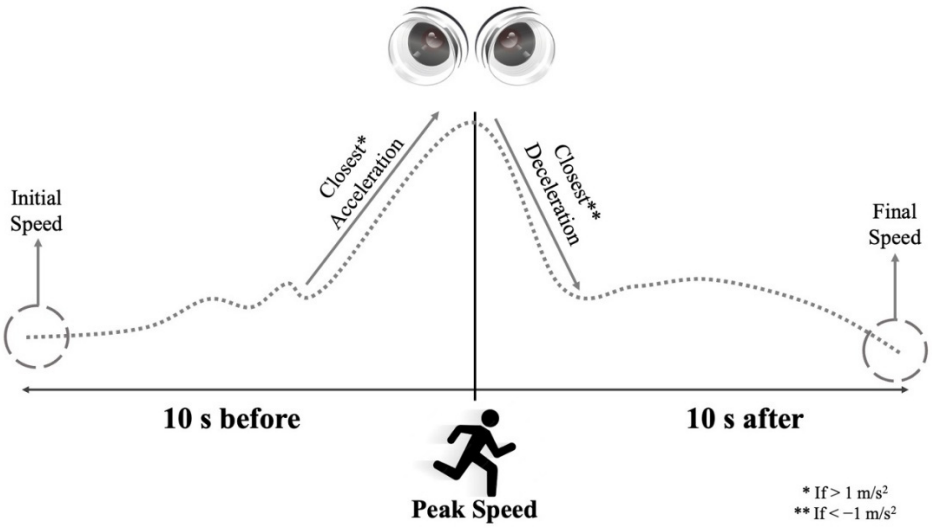



**Figure 1.** Diagram of the procedures.
*Note: the dotted line represents the increases and decreases in running speed*

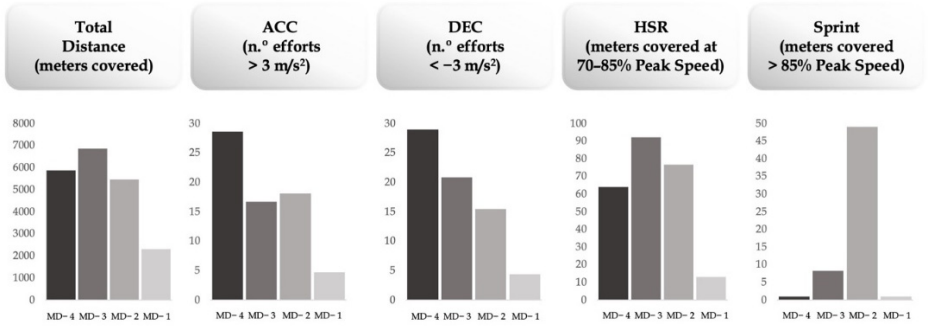



**Figure 2**. Average external load of the training sessions.
*Note: MD−4: four days before the match-day; MD−3: three days before the match-day; MD−2: two days before the match-day; MD−1: one day before the match-day; ACC: acceleration; DEC: deceleration; HSR: High-Speed Running. Of note: the % of peak speeds refers to percentages of the highest speed measured with GPS devices during matches and training sessions and were used to monitor the distances covered at high speeds as part of the team's regular routine*

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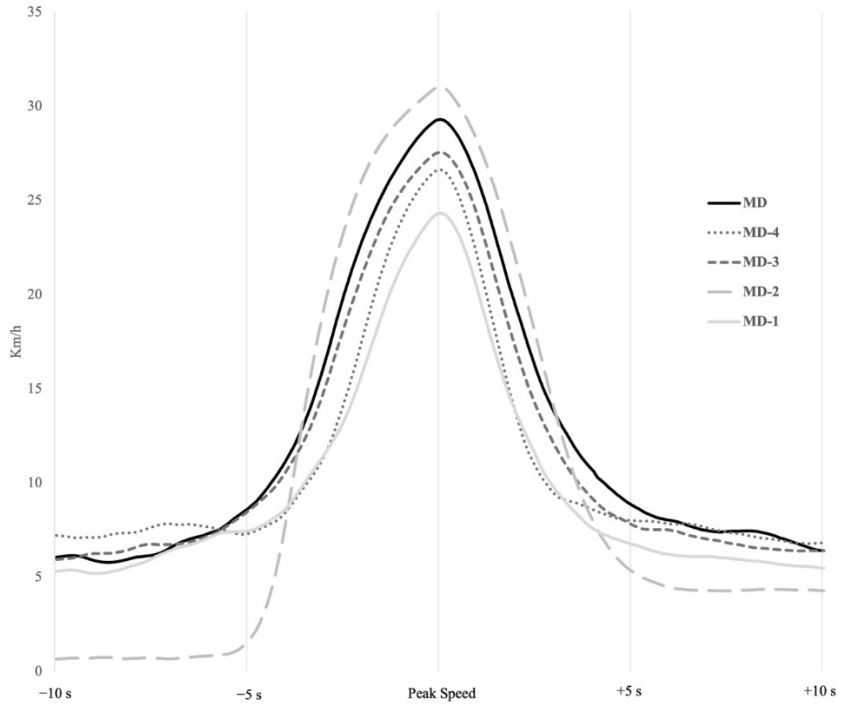



**Figure 3**. Mean speeds registered during each millisecond during the 20-s window analysis of the peak speed.
*Note:MD−4: four days before the match-day; MD−3: three days before the match-day; MD−2: two days before the match-day; MD−1: one day before the match-day; MD: match-day*

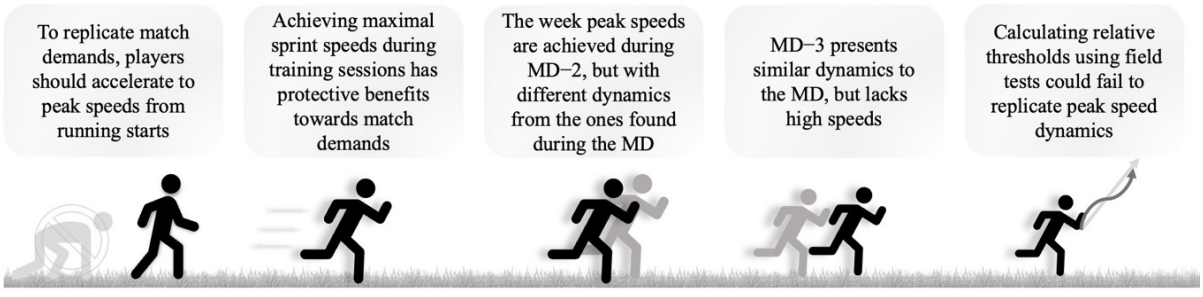



**Figure 4**. Summary of the practical implications.
*Note:MD−3: three days before the match-day; MD−2: two days before the match-day; MD: match-day*

## Discussion

Several studies have previously highlighted the importance of displacements near individual peak speeds, with a special focus on injury risk (Aiello et al., 2023; Malone et al., 2018). Specifically, when athletes approach these speeds, the hamstring muscles are subjected to extremely high loads (Higashihara et al., 2010, 2018), especially during the swing phase of sprinting, which requires intense lengthening of the hamstrings (Chumanov et al., 2011; Kenneally-Dabrowski et al., 2019). Considering the high prevalence of hamstring injuries in soccer (Diemer et al., 2021; Ekstrand et al., 2023), this topic is of crucial importance. In our study, we analyzed the peak speed over a 20-s window, capturing several key metrics: the peak speed itself, the initial speed (recorded 10 s before the peak speed), the final speed (recorded 10 s after the peak speed), the last acceleration occurring before peak speed (if > 1 $m/s^2$), and the first deceleration occurring after peak speed (if < −1 $m/s^2$). This approach provides a more comprehensive understanding of the physical demands associated with peak speed efforts. Our analysis focused on comparing these variables across different days of the microcycle (MD−4, MD−3, MD−2, MD−1, and MD). This method can offer practitioners valuable and practical insights into the variations and demands of peak speed efforts throughout the training cycle.

The main findings of the present study were that the highest peak speed was recorded during the MD−2 training session, whereas both initial speed and final speed were higher during the MD−4 training session. This partly confirms our initial hypotheses. In terms of accelerations and decelerations, the acceleration preceding the peak speed displayed higher magnitude during both the MD−4 and the MD−2 sessions, while higher deceleration magnitude was observed during the MD−4 session. Finally, we found that CDs reached lower peak speeds compared to FBs and FWs, and that CMs experienced lower deceleration magnitude than FBs, WMs, and FWs. To better understand the practical relevance of these findings, it is important to discuss the speeds and the accelerations (both positive and negative [decelerations]) separately.

Starting with speeds, a recent review has suggested that players should be exposed to sprints >95% of their maximal sprint speed during the microcycle, especially on MD−2 (Gómez-Piqueras and Alcaraz, 2024). This strategy can better prepare players for the potential demands of a match, ensuring consistent chronic exposure and avoiding sudden peaks in load (Griffin et al., 2020; Malone et al., 2017). This pattern was observed in our study, with higher peak speeds reached during MD−2. However, we also need to highlight the importance of initial speed and final speed. Specifically, we found that the MD exposed players to higher speeds in the 10 s before and after the peak speed. This indicates that during competition, players tend to run at higher speeds before reaching their peak speed. Although previous research has reported higher sprint and total distance demands during the middle of the microcycle (MD−3 and MD−2) compared to the training sessions closer to the match (MD−1) (Silva et al., 2023a), the MD is the day when players cover the most total distance and sprint distance (Grünbichler et al., 2019). Additionally, players also tend to reach higher peak speeds during matches compared to specific drills such as small-sided games, due to larger pitches, greater motivation, and the higher stakes associated with competition (Djaoui et al., 2017). Moreover, a previous study that analyzed peak speed using a similar 20-s window approach reported that speeds 10 s before and after the peak speed ranged approximately from 5 to 10 km/h (Silva et al., 2025). Our findings align with that study but underscore the differences in sessions where achieving peak speed is a primary objective, particularly on the MD−2. However, during this session, players reach higher speeds from standing starts, making it more comparable to a sprint test than to actual competition (Figure 3). Thus, to replicate the MD demands, practitioners could encourage players to accelerate from and decelerate to specific running speeds, rather than starting from a stationary position or coming to a complete stop. Additionally, the higher starting speeds observed during competition and other training sessions may reflect the greater unpredictability of game scenarios, whether in competitive matches or training formats like small- or large-sided games. However, reducing this unpredictability may be necessary to achieve the higher speeds recorded in the MD−2 session. Future studies should focus on developing training exercises that more accurately

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replicate match demands, particularly regarding the running speeds surrounding peak speed events.

The accelerations before the peak speed were consistently around 5 m/s² across all days, with magnitude regarded as high-intensity or close to maximal effort (Silva et al., 2022). This finding is particularly significant because as starting speed increases, the capacity for acceleration decreases (Sonderegger et al., 2016), resulting in higher metabolic demands (Osgnach et al., 2010) and potentially increasing the risk of hamstring injuries (Morin et al., 2021). For instance, achieving a maximum acceleration of 5 m/s² typically requires players to initiate the effort from a speed close to 14 km/h (Morin et al., 2021). Therefore, as starting speeds increase, the magnitude of acceleration achievable decreases accordingly. Interestingly, when comparing the magnitude of accelerations recorded during matches with those in training sessions, we found greater similarities between the MD and the MD−1 ( unclear effect size). Although the differences between the MD and the MD−2 (the speed training session) were small, it would be beneficial to expose players to accelerations from higher starting speeds. This preparation would help them meet the high metabolic and muscular demands they will face during matches by replicating the speed patterns observed during play. However, decelerations present different challenges, as these efforts impose high eccentric muscle actions. The total exposure to ground reaction forces is nearly three times greater in magnitude during the initial steps of a maximal deceleration compared to the initial steps of an acceleration (Harper et al., 2022). Decelerations are also one of the most common mechanisms preceding non-contact anterior cruciate ligament injuries (Harper et al., 2022). In our study, we found higher deceleration magnitude values during the MD−4 session compared to the MD (small effect size), and similar deceleration magnitude values during the MD−2 and MD sessions (unclear effect size). This provides an important insight as players of the investigated team were exposed to higher decelerations during the training week (MD−4) and replicated the MD effort during the speed training session (MD−2). By exposing players to higher or similar deceleration demands during training sessions, practitioners develop a protective mechanism by increasing the players' preparedness for the match demands (McBurnie et al., 2022). Nevertheless, due to the unpredictability of matches (Hill-Haas et al., 2008), practitioners also need to replicate match demands (Castillo-Rodríguez et al., 2020) by providing varied and unpredictable stimuli.

Regarding the importance of replicating match demands, we should also highlight the comparison between playing positions. When preparing for peak speed efforts, practitioners should consider the individual needs of each player. Specifically, FB, WM, and FW players may need to reach higher peak speeds and higher decelerations than CD and CM players. Consistently with this, previous research has reported higher acceleration and deceleration demands for wider positions (Silva et al., 2022). However, different findings have been reported regarding match peak speed: FWs and WMs have been found to reach higher peak speeds during matches (Al Haddad et al., 2015). Additionally, FWs and CDs have been observed to reach lower peak speeds, and FBs and WMs have been found to reach higher peak speeds (Abbott et al., 2018; Asian-Clemente et al., 2024; Silva et al., 2025).

The challenge of choosing specific moments, such as using a 20-s window to measure peak speed, is that other significant occurrences may be neglected. For instance, a high-speed movement could be achieved during training sessions or matches but excluded from the analysis if it falls outside this time window. Those speeds could exhibit different patterns, although our findings are closely related to a previous study that utilized a similar analysis but involved a different team and country (Silva et al., 2025), suggesting that this might not be the case. Moreover, future research could confirm this by replicating the analysis. Finally, with a larger sample size, a more specific analysis could be conducted regarding the individual characteristics of each playing position.

## Practical Implications

This study offers a focused analysis of peak speed efforts during various soccer activities. Specifically, the findings underscore the coaching staff's goal to replicate match demands during training. In addition to emphasizing high speeds, accelerations, and decelerations, players should also be exposed to accelerations towards peak speeds from running starts, thereby replicating the dynamics observed during matches. This can be incorporated into the MD−2 session through

speed-focused drills, such as those emphasizing transition situations. Additionally, players could also benefit from performing decelerations to running speeds close to 5 or 6 km/h instead of coming to a complete stop. However, training sessions should also include decelerations with very high magnitude to ensure proper preparedness for the unpredictability of matches. A summary of the practical implications is presented in Figure 4.

## Conclusions

This study provides valuable insights into the peak speed and acceleration profiles of soccer players across different training sessions. The results revealed that the highest peak speed occurred during the MD−2 session, whereas both initial and final speeds were greater in the MD−4 sessions. These findings highlight distinct movement patterns across sessions. Notably, accelerations leading up to peak speed showed greater magnitude values in both MD−4 and MD−2 sessions, while the most intense decelerations were observed on the MD−4. Positional differences were also evident, with CDs reaching lower peak speeds than FBs and FWs, and CMs experiencing lower deceleration magnitude than FBs, WMs, and FWs. These findings reinforce the importance of designing training drills that closely mimic match scenarios.

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***Informed Consent:*** Informed consent was obtained from all participants included in the study.

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