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# Differences in Accelerations and Decelerations Across Intensities in Professional Soccer Players by Playing Position and Match-Training Day

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**Abstract**

Accelerations and decelerations are critical components of soccer performance, reflecting mechanical load and injury risk, with understanding positional and temporal variations essential for optimizing training prescription. This study analyzed acceleration and deceleration demands in professional soccer players across playing positions and training microcycle phases. Twenty-five professional soccer players (26.6 ± 4.50 years) from a Spanish Second Division team were monitored using 18 Hz GPS STATSports (Newry, UK) devices during 16 training sessions and 4 official matches over four weeks. Accelerations and decelerations were categorized into six intensity zones (Z1–Z6, 0.5–1 to 5–10 $m/s^2$), with players grouped by position: central defenders (CD), full-backs (FB), central midfielders (CM), attacking midfielders (AM) and forwards (FW). Match day (MD) significantly affected all variables ($F > 4.75$; $p < 0.001$, $\omega_p{}^2 = 0.13–0.42$), with accelerations showing higher values at MD-2 for Z1, MD for Z2, MD-4 and MD for Z3–Z4, consistently reaching lowest values at MD-1. Decelerations peaked at MD across Z2–Z6, with MD-1 showing minimal preparation values. Positionally, FB exceeded other positions in low-intensity accelerations and decelerations (Z1–Z2), while CM dominated high-intensity decelerations (Z4–Z6). Total accelerations differed significantly by position (FB: 579 ± 163 vs. AM: 494 ± 184 events, $p < 0.05$). Training acceleration loads adequately replicate match demands, but deceleration preparation remains insufficient, representing a potential injury risk. Position-specific protocols should emphasize deceleration conditioning, particularly for CM and FB.

**Keywords:** speed changes; positional demands; training load; performance analysis; GPS tracking; mechanical load; injury risk

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## 1. Introduction

Soccer is an intermittent sport, where players must perform a wide variety of locomotor and technical actions in conditions of tactical complexity and physical fatigue, due to physical demands and high intensities [1,2]. Accelerations, decelerations, changes of direction and high-speed sprints are some of the actions players must perform over the course of a 90-min match, with players performing hundreds of short-duration, high-intensity actions, all superimposed on a background of lower-intensity movements [3]. Accelerations and decelerations provides valuable insight into player workload, as these rapid changes in speed are strong contributors to both neuromuscular strain and the subjective experience of physical exertion, varying notably by playing position [4–6]. Recent research has demonstrated that the frequency and intensity distribution of these actions varies significantly across different competitive levels and age categories [7]. These repeated changes of actions generate different mechanical loads, varying in magnitude and structure from those imposed by running at constant speed, placing considerable stress on aerobic and anaerobic energy systems [8,9].

Over the last years, total distance and time spent at high speeds have been the distance and speed-based metrics used to analyze performance in soccer [10]. However, simply taking these variables into account to address physical demands alone provides an incomplete picture [4]. Training load can be differentiated into external load (referring to the overall activities of a player) and internal load (encompassing the psycho-physiological stress imposed on the player's body) [11,12]. External load provides objective measures of mechanical work performed, while internal load reflects individual physiological responses to training stimuli [13]. Particularly relevant components of external loading due to their frequency, intensity and metabolic cost are accelerations and decelerations, which require rapid changes in velocity [8,14]. Decelerations, in particular, involve high eccentric muscle actions. These actions are associated with muscle damage, neuromuscular fatigue and an increased risk of injury, as they generate significant mechanical stress [15,16].

High-intensity decelerative actions have been increasingly linked in recent years to injury risk in elite soccer [15]. Accumulating a high number of decelerations over short periods of time is associated with an increased risk of injury [17]. On the other hand, off-ball movements in certain positions, such as lateral strides and backward runs in defenders, are very frequent and contribute significantly to injury mechanisms due to the high neuromuscular load in unstable or visually limited conditions [18]. In order to prevent non-contact injuries, the acute: chronic workload ratio model also highlights the importance of controlling sudden changes in acceleration and deceleration demands [17]. This ratio compares recent workload (acute: 1 week) to longer-term workload (chronic: 3–4 weeks), with ratios > 1.3 associated with increased injury risk [17].

Numerous studies have analyzed variations in external loading by position in elite soccer [4,19]. On the one hand, FB and open midfielders are exposed to higher volumes of high-intensity efforts and frequent acceleration actions, while CD show more conservative movements [20]. Through these differences, the tactical responsibilities and positioning of players on the field can be observed, suggesting an individualized load prescription to optimize adaptation and reduce the risk of overload [19,20].

In addition, loading demands vary not only by position, but also throughout the competitive microcycle. In order to reach peak physical demands at the beginning of the week and decrease towards match day (MD) to facilitate recovery and match preparation, training programs are often periodized [21,22]. Furthermore, strength- and endurance-based sessions at the beginning of the week show significantly higher acceleration and deceleration loads compared to pre-match sessions [23]. Similarly, one study showed that acute loading, monotony and tension of accelerations and decelerations peaked during pre-season, progressively decreasing throughout the season, reinforcing the need for longitudinal monitoring of loading [20].

Due to muscle fatigue, acceleration and deceleration performance deteriorates over the course of a match, with up to a 21% reduction in these actions performance observed in the final stages of professional matches [24]. Therefore, in addition to their usefulness as performance metrics, they are also useful as indirect markers of fatigue and recovery status. In recent years, numerous studies have analysed the frequency, intensity and positional differences in acceleration and deceleration during matches [4,6,7,19,20], as well as their load distribution throughout the training microcycles [21–23]. However, integrative analyses that examine both dimensions (position and training day) simultaneously in a unified sample are still lacking. This limits the ability to prescribe position- and context-specific training loads that accurately reflect match demands.

Therefore, the aim of the present study is to analyse differences in acceleration and deceleration demands among professional soccer players, stratified by playing position and by training session timing across the week. The authors hypothesized that: (1) acceleration and deceleration demands would vary across the training microcycle, with peak loads during early-week sessions and lowest at MD-1; (2) playing positions would demonstrate distinct profiles reflecting their tactical roles; and (3) training sessions would inadequately replicate match deceleration demands in high-intensity zones.

## 2. Materials and Methods

### *2.1. Design*

This study employed a prospective observational design to examine external load patterns in professional soccer players across competitive matches and training sessions. A rotational sampling approach was utilized during training sessions, with 10 players representing different positional roles monitored per session to ensure balanced representation. For match analysis, data collection focused exclusively on starting outfield players to standardize competitive demands. Training sessions were categorized according to their proximity to MD (MD-4 through MD-1), reflecting typical microcycle structures where early-week sessions emphasize higher loads while late-week sessions feature reduced intensity. This longitudinal monitoring approach across four consecutive weeks provided comprehensive insight into external load demands across different contexts of professional soccer participation [25,26].

### *2.2. Participants*

This study involved 25 male professional soccer players (age: 26.6 $\pm$ 4.50 years; height: 181.4 $\pm$ 6.37 cm; weight: 74.5 $\pm$ 7.22 kg), all of whom were contracted to the same Spanish Second Division team during the 2017–2018 season, who participated voluntarily. Based on previous position-specific classifications [4,27], players were grouped into five categories: CD (seven players), FB (four players), CM (four players), AM (five players), and FW (five players). Player inclusion was based on positional role within the team's tactical structure. Because of a pattern likely linked to the distinct characteristics of their role, goalkeepers are frequently omitted from scientific analyses. Due to the specialized demands of their position, goalkeepers are subject to reduced physical workloads compared to outfield players [28]. Specifically, inclusion was limited to the ten outfield players who accumulated the highest total match minutes, with a minimum threshold of 60 min played during official competition each week. The performance and load metrics from these selected players were then systematically compared to the training data recorded during the corresponding week. Data collection was conducted in the sixth month of the competitive season. The full seventh-month period was segmented into one month of pre-season and six months of official competition. During this time, players followed a structured training schedule consisting of four strength and integrated soccer-specific sessions per week, totaling approximately ten hours of planned training. Additionally, each weekly cycle included one official competitive match. Both, training and competition were held on a natural grass surface. Prior to the beginning of the investigation, written informed consent was obtained from all participating players. This study received approval from the Research Ethics Committee of the Aragon Autonomic Community (PI21/375) and was conducted in accordance with the principles outlined in the Declaration of Helsinki.

*2.3. Equipment and External Load Metrics*

External load variables were captured using 18 Hz GPS devices from STATSports (Newry, UK), integrated into custom-designed vests worn on the upper back. These devices have demonstrated high validity and low measurement error for assessing total distance and peak speed in team-sport settings [29]. The data were processed and analyzed using STATSports Apex software (version 5.0).

The external workload was assessed using acceleration-based indicators. Acceleration and deceleration actions were categorized by magnitude into six zones: 0.5–1, 1–2, 2–3, 3–4, 4–5, and 5–10 m/s$^2$, following previous studies [8,14]. The number of actions in each zone (Acc_Z1–Acc_Z6 and Dec_Z1–Dec_Z6) was recorded. Additionally, the total number of accelerations/decelerations in each zone and the training impulse (TRIMPS) index have been included. The TRIMPS index for accelerations and decelerations was calculated by multiplying the number of events in each zone by the corresponding zone value (e.g., 5.70 events in Z6 $\times$ 6 = 34.2), with the sum of all zones representing the total TRIMPS score.

*2.4. Procedures*

All player profiles, including anthropometric data and positional information, were logged into the STATSports Apex system (Newry, UK). The physical dimensions of the training and competition fields were manually configured within the software to ensure spatial accuracy. GPS devices were activated 10 min before each session and inserted into shoulder-mounted vests specifically designed for tracking purposes. Data collection covered the entire period in which each player was actively participating.

2.4.1. Matches

Four official league matches were included in the analysis. The team consistently employed a 1-4-4-2 diamond formation (Figure 1), comprising CD (two players), FB (two players), CM (three players), AM (one player), and FW (two players). Tracking began at kickoff and ended upon substitution or match conclusion. A total of 40 data entries were collected, distributed across different playing positions as follows: CD—8 records, FB—8 records, CM—12 records, AM—4 records, and FW—8 records. This distribution reflects the positional representation within the study sample. To avoid data overlap, matches selected were spaced by at least five days.

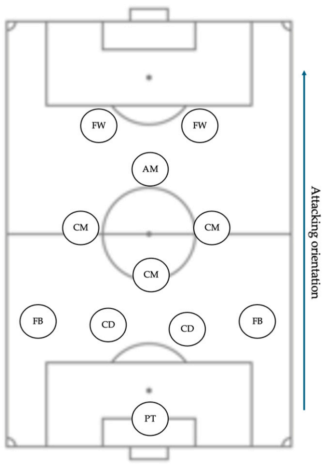


**Figure 1.** 1-4-4-2 Tactical formation diagram.

#### 2.4.2. Training Sessions

Monitoring was conducted across 16 training sessions held over four consecutive weeks, with four sessions recorded per week. These sessions reflected a typical microcycle structure, including early-week sessions with higher neuromuscular and metabolic load (e.g., strength or endurance-based work) and late-week sessions characterized by reduced intensity and volume. This structure aligns with periodization strategies described by previous studies [23,30]. These sessions were categorized according to their temporal proximity to MD, specifically as MD-4, MD-3, MD-2, and MD-1. A total of 160 data entries were recorded throughout the study. These were distributed according to playing position as follows: CD—32 entries, FB—32 entries, CM—48 entries, AM—16 entries, and FW—32 entries. This breakdown reflects the overall positional representation within the dataset.

### *2.5. Statistical Analysis*

Descriptive statistics are presented as mean ± standard deviation for all variables. Prior to analysis, assumptions of normality were assessed using tests of homogeneity and homoscedasticity to verify the appropriate distribution of the data. Given the repeated measures design with participants measured across multiple match days and the nested structure of the data with playing positions as a between-subjects factor, a mixed-effects model was employed to account for the correlation between repeated observations within participants and to handle missing data appropriately. The mixed-effects model included match day as a within-subjects factor, playing position as a between-subjects factor, and participant as a random effect to control for individual differences [31]. Post-hoc pairwise comparisons were conducted using Bonferroni correction to control for multiple comparisons, with the significance level adjusted from $\alpha = 0.05$ by dividing by the number of pairwise comparisons performed for each variable. Effect sizes for the mixed model F-statistics were calculated using partial omega squared ($\omega_p{}^2$), with values interpreted as small (0.01), medium (0.06), and large (0.14) effects. Cohen's d was calculated for post-hoc comparisons, with effect sizes interpreted as small (0.20), moderate (0.60), large (1.20) and very large (2.00) [32]. All statistical analyses were performed using JAMOVI (Version 2.3, Sydney, Australia), while graphical representations were created using GraphPad Prism (Version 9.0, San Diego, CA, USA). Statistical significance was set at $p < 0.05$.

## 3. Results

### *3.1. Accelerations and Decelerations Demands Profile in Soccer*

The accelerations and decelerations data across six intensity zones revealed distinct frequency distributions. Accelerations were highest in Z1 (206 ± 74.3 events) and Z2 (195 ± 61.1 events), followed by Z3 (86.7 ± 28.4 events), Z4 (36.5 ± 15.0 events), Z5 (11.6 ± 6.81 events), and Z6 (2.25 ± 2.54 events). Decelerations showed a similar pattern with Z1 recording 228 ± 74.7 events, Z2 with 206 ± 61.8 events, Z3 with 73.3 ± 24.8 events, Z4 with 32.5 ± 14.3 events, Z5 with 13.1 ± 7.43 events, and Z6 with 5.70 ± 4.38 events. The minimum values for accelerations ranged from 46 events in Z1 to 0 events in Z4, Z5, and Z6, while maximum values ranged from 498 events in Z1 to 12 events in Z6. For decelerations, minimum values ranged from 71 events in Z1 to 0 events in Z5 and Z6, with maximum values ranging from 545 events in Z1 to 21 events in Z6. Total accelerations averaged 538 ± 151 events with corresponding TRIMPS values of 1074 ± 296, while total decelerations averaged 558 ± 152 events with TRIMPS values of 1089 ± 307 (see Supplementary Table S1).

*3.2. Effect of Contextual Variables in Accelerations and Decelerations Profile*

Table 1 presents the mixed-effects model results examining the effects of match day, playing position, and their interaction on accelerations and decelerations variables. The analysis revealed significant main effects of match day across all variables, with F-values ranging from 4.75 to 38.17 (all $p < 0.001$ except Acc_Z6 with $p = 0.001$) and large effect sizes for most variables ($\omega_p{}^2 = 0.13$–$0.42$), indicating substantial variations in acceleration and deceleration patterns across the different match days. Playing position demonstrated significant effects on several variables, particularly Acc_Z2 ($F = 4.82$, $p < 0.01$, $\omega_p{}^2 = 0.05$), Acc_Z5 ($F = 2.65$, $p = 0.04$, $\omega_p{}^2 = 0.02$), and all deceleration zones except Dec_Z1, with Dec_Z2 showing the largest effect ($F = 5.26$, $p < 0.001$, $\omega_p{}^2 = 0.06$), though effect sizes were generally small to moderate. Total and TRIMPS measures for both accelerations and decelerations also showed significant positional differences ($p < 0.05$) with small effect sizes ($\omega_p{}^2 = 0.02$). Notably, no significant interaction effects were observed between match day and playing position for any variable (all $p > 0.05$), suggesting that the patterns of change across match days were consistent regardless of playing position.

**Table 1.** Mixed-effects model results for accelerations and decelerations variables across match days and playing positions.

| Variables | Match-Day | | Playing Position | | Interaction | |
|---|---|---|---|---|---|---|
| | *F (p)* | $\omega_p{}^2$*(Effect)* | *F (p)* | $\omega_p{}^2$*(Effect)* | *F (p)* | $\omega_p{}^2$*(Effect)* |
| Acc_Z1 | 12.86 (<0.001) | 0.19 (large) | 1.72 (0.15) | 0.00 | 0.37 (0.99) | 0.00 |
| Acc_Z2 | 26.28 (<0.001) | 0.32 (large) | 4.82 (<0.01) | 0.05 (small) | 1.36 (0.17) | 0.00 |
| Acc_Z3 | 38.17 (<0.001) | 0.42 (large) | 2.16 (0.08) | 0.01 (small) | 1.24 (0.24) | 0.00 |
| Acc_Z4 | 17.70 (<0.001) | 0.25 (large) | 0.79 (0.54) | 0.00 | 0.93 (0.54) | 0.00 |
| Acc_Z5 | 8.57 (<0.001) | 0.13 (large) | 2.65 (0.04) | 0.02 (small) | 0.92 (0.54) | 0.00 |
| Acc_Z6 | 4.75 (0.001) | 0.07 (moderate) | 0.74 (0.57) | 0.00 | 1.14 (0.33) | 0.00 |
| Dec_Z1 | 13.85 (<0.001) | 0.21 (large) | 1.80 (0.13) | 0.01 (small) | 0.60 (0.88) | 0.00 |
| Dec_Z2 | 23.49 (<0.001) | 0.29 (large) | 5.26 (<0.001) | 0.06 (moderate) | 1.07 (0.40) | 0.00 |
| Dec_Z3 | 27.08 (<0.001) | 0.33 (large) | 3.82 (0.005) | 0.04 (small) | 1.23 (0.25) | 0.00 |
| Dec_Z4 | 21.10 (<0.001) | 0.28 (large) | 4.25 (0.003) | 0.05 (small) | 0.84 (0.64) | 0.00 |
| Dec_Z5 | 19.64 (<0.001) | 0.26 (large) | 2.51 (0.04) | 0.02 (small) | 1.50 (0.11) | 0.00 |
| Dec_Z6 | 17.03 (<0.001) | 0.23 (large) | 3.36 (0.01) | 0.03 (small) | 1.48 (0.11) | 0.00 |
| Total_Acc | 22.38 (<0.001) | 0.30 (large) | 2.68 (0.03) | 0.02 (small) | 0.73 (0.77) | 0.00 |
| Total_Dec | 22.99 (<0.001) | 0.30 (large) | 2.59 (0.04) | 0.02 (small) | 0.83 (0.65) | 0.00 |
| TRIMPS_Acc | 28.17 (<0.001) | 0.35 (large) | 2.54 (0.04) | 0.02 (small) | 0.79 (0.70) | 0.00 |
| TRIMPS_Dec | 31.64 (<0.001) | 0.38 (large) | 2.43 (0.05) | 0.02 (small) | 0.87 (0.60) | 0.00 |

**Note.** Acc = Accelerations; Dec = Decelerations; Z1–Z6 = Intensity zones 1–6; TRIMPS = Training Impulse; $F$ = F-statistic; $p$ = $p$-value; $\omega_p{}^2$ = partial omega squared effect size.

3.2.1. Match Day

Figure 2 presents the comprehensive analysis of acceleration and deceleration variables across the five-day training microcycle leading up to match day. The data reveal distinct temporal patterns that reflect the periodized training approach, with notable variations in neuromuscular demands across different intensity zones.

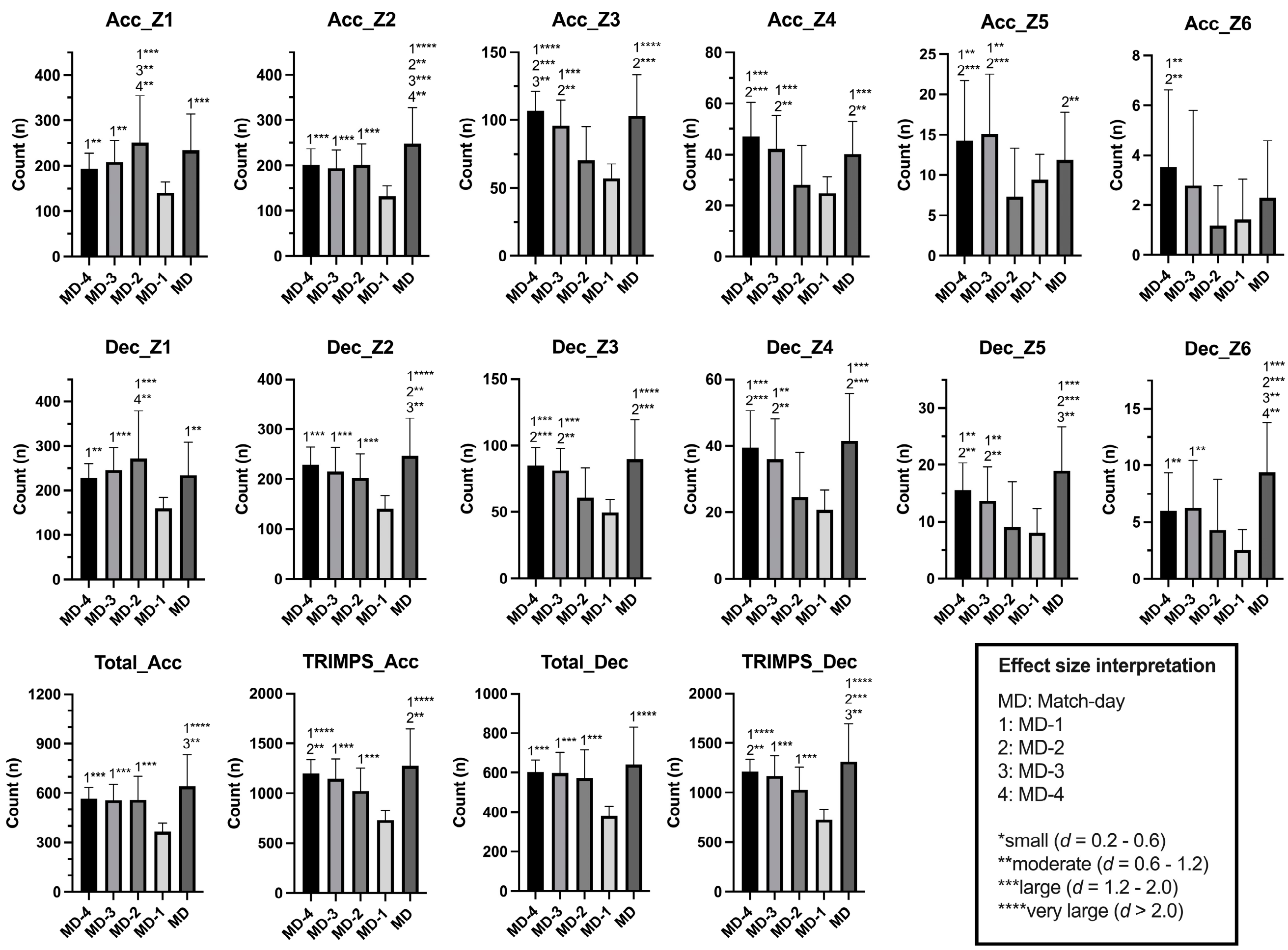


**Figure 2.** Accelerations and decelerations variables across match days (MD-4, MD-3, MD-2, MD-1, and MD).

*Accelerations*

- Low-intensity (Z1–Z2): Zone 1 accelerations reached their lowest value at MD-1 before significantly increasing at MD-2 and MD ($p < 0.001$). Similarly, Zone 2 accelerations showed their lowest values at MD-1 compared to substantially higher frequencies on MD ($d = 2.48$) and MD-3 ($d = 1.21$).
- High-intensity (Z3–Z6): Higher intensity accelerations exhibited a more complex temporal distribution. Zone 3 accelerations peaked during the early microcycle phase (MD-4) and MD, both significantly exceeding MD-1 values ($d = 2.30$–$2.45$, $p < 0.001$). Zone 4 accelerations followed a similar pattern, with MD-4 showing the highest frequency compared to the reduced load at MD-1 ($d = 1.60$, $p < 0.001$). The most intense acceleration zones (Z5-Z6) showed more sporadic patterns, with Zone 5 peaking at MD-3 and demonstrating significant differences from MD-2 ($d = 1.27$, $p < 0.001$).

*Decelerations*

- Low-intensity decelerations (Z1–Z2): MD-1 representing the lowest load before the substantial increase on match day ($p < 0.001$).
- High-intensity decelerations (Z3–Z6) demonstrated progressive increases from MD-1 to match day across all zones. Zone 3 decelerations nearly doubled from MD-1 to MD ($p < 0.001$), while Zone 4 showed similar patterns ($d = 1.80$, $p < 0.001$). The most intense deceleration zones (Z5–Z6) exhibited the largest relative increases, with Zone 6 showing a nearly four-fold increase from MD-1 to MD ($d = 1.91$, $p < 0.001$).

*Cumulative Load*

- Total accelerations and decelerations provided clear evidence of the periodization strategy's effectiveness. Both metrics reached their lowest values at MD-1 before dramatically increasing on match day ($d = 2.13$; $p < 0.001$).
- TRIMPS values corroborated these findings, with acceleration TRIMPS following the same temporal pattern (MD-1 vs. MD, $p < 0.001$) and deceleration TRIMPS showing identical trends (MD-1 vs. MD, $p < 0.001$). The effect sizes ranged from moderate to very large ($d = 1.27$–$2.54$), indicating substantial practical significance.

#### 3.2.2. Playing Positions

Figure 3 illustrates the position-specific neuromuscular demands across playing positions, revealing distinct tactical and physiological requirements that align with each role's on-field responsibilities. The data demonstrate that defensive positions generally exhibiting higher volumes of lower-intensity actions, while CM showed greater engagement in high-intensity directional changes.

*Accelerations*

- Low-intensity (Z1–Z2): While Zone 1 accelerations showed no significant positional differences ($p = 0.15$), FB recorded the highest absolute values compared to both AM and FW. This pattern became statistically significant in Zone 2, where FB demonstrated substantially higher acceleration frequencies than both AM ($d = 0.88$, $p < 0.01$) and FW ($d = 0.81$).
- High-intensity (Z3–Z6): Zone 3 accelerations, while not reaching statistical significance ($p = 0.08$), showed CM with the highest values, reflecting their role as the primary transition players between defensive and offensive phases. Zone 4 displayed relatively uniform distribution across positions ($p = 0.54$), suggesting that explosive acceleration demands are consistent regardless of tactical role. Interestingly, Zone 5 revealed unexpected positional differences ($p = 0.04$), with CD significantly exceeding AM ($d = 0.89$).

*Decelerations*

- Low-intensity (Z1–Z2): Deceleration patterns exhibited more pronounced positional distinctions than accelerations, particularly in moderate intensity zones. Zone 1 decelerations, while not statistically different ($p = 0.13$), showed FB with the highest values, establishing them as the most deceleration-demanding position. This pattern reached statistical significance in Zone 2 ($p < 0.001$), where FB substantially exceeded both AM ($d = 1.09$) and FW ($d = 0.82$).
- High-intensity (Z3–Z6): CM demonstrated superior engagement compared to other positions. Zone 3 decelerations showed CM significantly outperforming AM ($d = 0.79$, $p = 0.005$). Zone 4 decelerations ($p = 0.003$) revealed CM significantly exceeding both FB ($d = 0.74$) and AM ($d = 0.77$). The pattern continued in Zone 6 ($p = 0.01$), where CM again obtained higher values than AM ($d = 0.57$). Notably, Zone 5 decelerations showed CD significantly exceeding FB ($d = 0.58$, $p = 0.04$).

*Cumulative Load*

- Total accelerations and decelerations revealed FBas the most demanding position in accelerations and decelerations. Total accelerations differed significantly between positions ($p = 0.03$), with FB demonstrating substantially higher values than AM ($d = 0.74$). This pattern was mirrored in total decelerations ($p = 0.04$), where FB again exceeded AM ($d = 0.72$).

- TRIMPS values corroborated these positional differences, with both acceleration and deceleration TRIMPS showing significant positional variations ($p$ = 0.04 and $p$ = 0.05, respectively). FB consistently demonstrated the highest TRIMPS values, followed by CD and CM, with AM showing the lowest values (acceleration: −16.5%; deceleration: −14.6%).

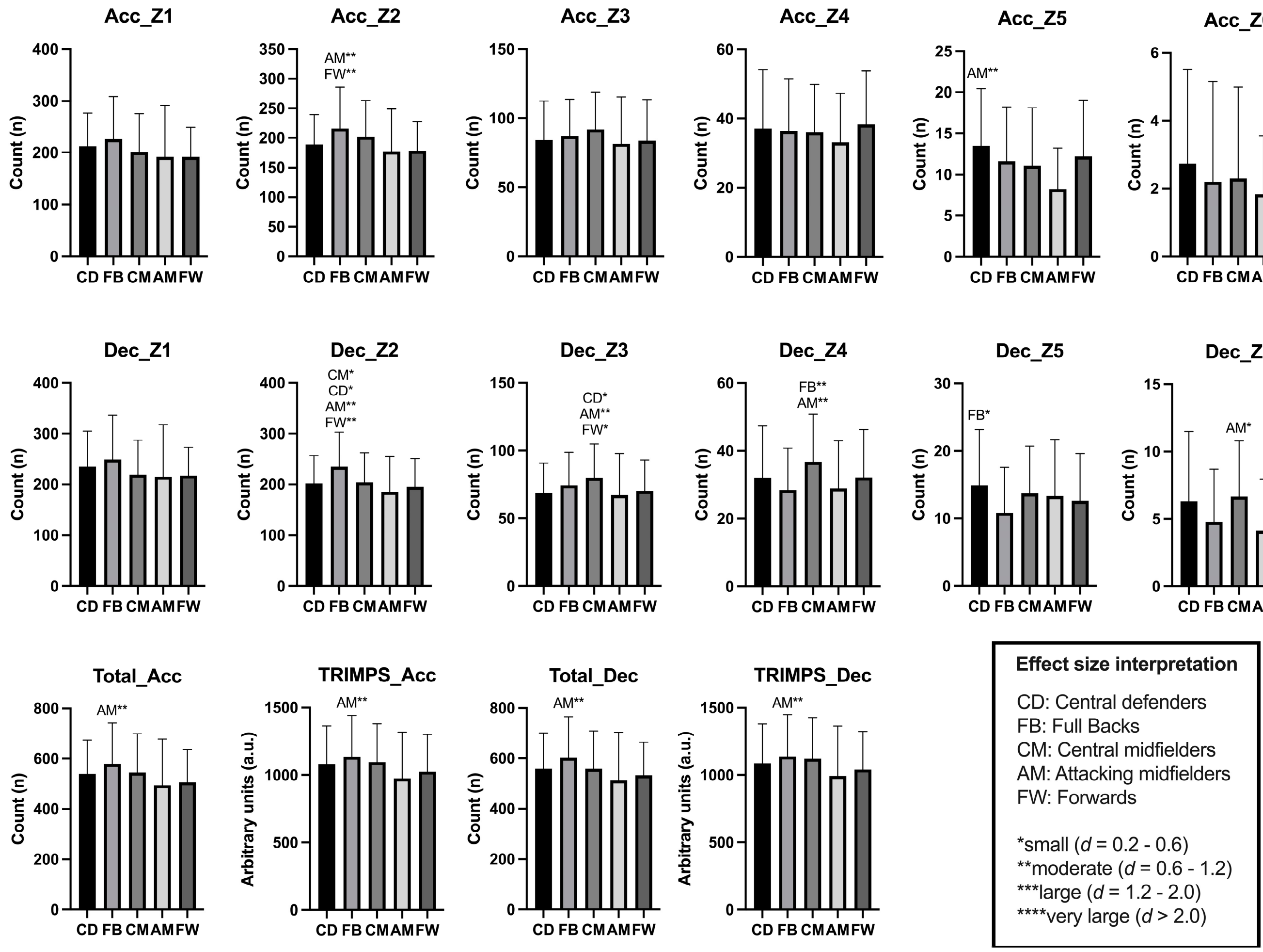


**Figure 3.** Accelerations and decelerations variables across playing positions: central defenders (CD), full−backs (FB), central midfielders (CM), attacking midfielders (AM), and forwards (FW).

## 4. Discussion

This study provides comprehensive insights into acceleration and deceleration demands in professional soccer, revealing three critical findings for training optimization and injury prevention. First, acceleration and deceleration loads follow distinct periodization patterns throughout the microcycle, with training sessions consistently failing to adequately prepare players for the high-intensity deceleration demands experienced during matches. Second, playing positions demonstrate unique neuromuscular profiles that reflect modern tactical evolution, with FB experiencing the highest cumulative loads while CM face distinct high-intensity deceleration challenges in congested spaces. Finally, the substantial mismatch between training and competition deceleration demands, particularly in high-intensity zones, represents a critical gap in current periodization approaches that may increase injury risk and compromise performance preparation.

### 4.1. Effect of Match Day and Training Periodization

The results of the present study demonstrated that acceleration and deceleration demands across the training microcycle follow distinct periodization patterns, with the highest loads occurring during MD-4 and MD-3, followed by systematic load reduction culminating in the lowest values at MD-1 before peak demands on match day. These findings align with established periodization strategies documented in previous literature, which consistently report high neuromuscular demands during early-week training sessions (MD-4 and MD-3) that progressively decrease toward MD-1, before reaching peak values during competitive matches [25,33]. This trend complies with accepted training standards, which reflect that strength and power work carried out earlier in the training week requires much greater acceleration exigencies than that carried out closer to MD [23,25]. Additional support comes from a recent soccer training systematic review by Silva et al. [34], who confirm that acceleration and deceleration exigencies invariably diminish closer to MD, thus corroborating our temporal findings.

Worst finding relates to insufficiency in training for needs of deceleration during training exercises. Though values for MD assessed deceleration were highest for all intensities, training exercises always failed to reach those needs, MD-1 exhibiting poorest values before resultant sharp rise needed when in competition. Such mismatching occurs most severely at high-intensity areas of deceleration (Z4–Z6), where values needed in matches were almost twice or three times those experienced in training exercises. Our results are at odds with earlier work by Dalen et al. [4], who concluded more even distribution of accelerative and decelerative impulses between match play and training exercises by elite Norwegian footballers, signifying likely differences in process or status for competition. Also, Silva et al. [35] recently demonstrated that match requirements have more accelerative and decelerative qualities than whatsoever training drill, thus warranting our results of mismatch between competition and training fields. As decelerations involve high eccentric muscle actions associated with muscle damage, neuromuscular fatigue, and non-contact injuries (particularly ACL injuries and muscle strains) [15,16,18], the substantial training-match deceleration mismatch observed highlights inadequate preparation in current periodization approaches.

Significantly high increases in deceleration requirements during match play were found, notably a four-fold increase in Z6 decelerations ($2.55 \pm 1.81$ vs. $9.38 \pm 4.40$ events), indicating that players are possibly not adequately conditioned to handle directional changes and rapid stoppages required in high-performance situations. Russell et al. [16] documented similar decreases in accelerative and decelerative abilities during competitive matches, recording up to 21% reduction during final stages of professional matches, while Harper and Kiely [15] expressed concerns about modern training routines inadequately preparing players for deceleration challenges. Recent research by Tsilimigkras et al. [36] verified that deceleration measures were strong predictors of non-contact injury risks in elite soccer players, and Bowen et al. [17] demonstrated that acute to chronic workload ratios for high-intensity exercises such as decelerations are strong predictors of injury vulnerability, particularly when multiple instances of high-speed deceleration occur within brief time intervals. Our data showing that match deceleration demands in high-intensity zones were two to four times higher than training values, combined with systematic review findings [37,38] indicating that rapid increases in deceleration loads under acute conditions increase injury risk when chronic loads remain low, confirm that current training periodization provides inadequate deceleration conditioning relative to competitive demands.

In addition, one-day prior to the match, both acceleration and deceleration loads were found to have their low values following that, there were significant increases during match day, and their effect size ranged between moderate to very large ($d$ = 1.27–2.54).

Akenhead et al. [39] also recorded patterns amongst footballers in the English Premier League, where training loads are highly concentrated during the onset of the week but peaking before subsequently decreasing towards match day. Such antecedent findings differ from reports that recorded sharp increases, since their findings hinted towards more gradual changes corresponding to incremental increases in loads. The recent findings of Branquinho et al. [40] portrayed that optimal weekly training for elite Brazilian footballers requires a sensitive balance between several physical stimuli, thus opposing current trends that recommend progressive reduction of load towards match day. Such distinguished variations between measures of training preparation and MD competitive requirements also reflect that current periodization templates are in need of reorganization to incorporate more detailed microcycle-wide training of deceleration, instead of merely recommending progressive reduction of load towards MD.

### 4.2. Effect of Playing Position and Tactical Formation

The study highlighted specific roles that had distinct patterns of accelerative and decelerative work, which are indicative of changing tactical requirements found in modern soccer. The full-back position showed peak physical effort in cumulative acceleration and deceleration work, considerably more than AM when measured by cumulative workload values. This finding complements current published work on full-back roles, which involve both defensive cohesion and offensive width, hence necessitating rapid high-intensity sprints and rapid transitional actions [19,20]. Our results support previous work by Bradley et al. [19] and Silva et al. [34] that wing roles have high requirements for acceleration and, consequently, also for their associated reverse action, deceleration. Our findings demonstrate that accelerations exceeded decelerations across most intensity zones (Z1–Z4), with only the highest intensity zones (Z5–Z6) showing greater deceleration frequencies than accelerations (Z5: 13.1 $\pm$ 7.43 vs. 11.6 $\pm$ 6.81 events; Z6: 5.70 $\pm$ 4.38 vs. 2.25 $\pm$ 2.54 events). These results align with recent findings in Czech academy players, which demonstrated that while accelerations predominate over decelerations at lower intensities (2–4 $m/s^2$), decelerations become more frequent at higher intensities (>4 $m/s^2$) [7]. This pattern supports the biomechanical reality that high-intensity decelerations are more frequently demanded in professional match situations for defensive actions, rapid directional changes, and tactical positioning.

Successful adoption of strategic 1-4-4-2 diamond shape prominently accentuates FB' multiple roles, clarifying low-intensity area (Z1–Z2) increases and significant shifts compared to AM ($d$ = 0.88 and 1.09 for Z2 accelerations and decelerations, respectively). Also, position-dedicated changes were recorded by Di Salvo et al. [10] and Oliva-Lozano et al. [41] based on tactical shape. Also, Forcher et al. [42] proved experimentally that formations that employ three defenders (e.g., 3-5-2) place greater physical requirements on FB and CD compared to formations that employ four defenders (e.g., 4-4-2), but sprinting requirements for FB and CM are relatively constant, regardless of formations.

Centrally deployed midfielders exhibited high levels of activity in regions of high-intensity deceleration (Z3–Z6), which were greater than other roles at positions of rapid directional changes and swift stopping. This finding parallels their essential transitional roles between defence and attack, which often involve changing direction to receive a pass, evade opponents, and subsequently pass the ball themselves. The high incidences of deceleration found in Z4 and Z6 ($p$ = 0.003 and $p$ = 0.01, respectively) are in keeping with current tactical approaches that place CM in high-density areas, consequently necessitating immediate accelerative and decelerative abilities [14,43]. Forcher et al. [42] found in their study that CM adjust to changes in tactical formations to a similar extent within various systems; nevertheless, their sprinting requirements are relatively invariant, indicating that high-intensity directional changes are attributes inherent to their position more than formation particularities.

CD have shown surprisingly high frequencies in certain high-intensity areas, including Z5 accelerations that were measured at 13.5 ± 6.93 times and Z5 deceleration at 14.9 ± 8.26 times, subsequently calling into question traditional notions of their defensive roles. These finding highlights changing roles of CD, who are more often overlapping in runs, especially when in possession-based tactics [20,44,45]. Forcher et al. [42] provide valuable knowledge by showing that certain CD formations, for example, 3-5-2, place considerably more physical burden upon CD than formations that employ four defenders, since CD need to pass more frequently and perform more high-intensity actions in current tactics.

Differently from some earlier investigations [4,27], this study finds notable uniformity in acceleration requirements across different positions situated in moderate-to-high movement levels (Z3–Z4), indicating that explosive acceleration abilities represent key attributes regardless of tactical roles. Though Dalen et al. found more distinct positional differences, Silva et al. [35] showed that position-specific training exercises lead to differentiated requisites for respective roles. Forcher et al. [42] put these findings in context by showing that formations that truly have similarly structured positions (e.g., 4-5-1 and 4-2-3-1) have little physical difference; however, position-specific requisites are still prevalent in all tactical systems. Their argument that position-specific analysis provides more practical knowledge than assessments based on team-wide analysis applies in this case and indicates that training models should incorporate role-specific training methods for deceleration that attend to individual position-specific requisites inherent to respective tactical systems.

Amassed workloads for acceleration and deceleration (for FB: 579 ± 163 and 602 ± 163 events, respectively) were substantially high compared to those recorded by Osgnach et al. [8] for Italian Serie A footballers. This difference could be attributed to differences in competition standards, tactical systems, or methods of measurement. More recent work examining Championship English data [46] found patterns that are commensurate with ours, in particular, that wide players have had higher cumulative workloads compared to their centrally oriented fellow players. These findings highlight the essential need to consider both tactical systems and changing dynamics of position roles when designing position-specific training approaches, particularly based on the shifting workload requirements that are part of modern soccer.

### *4.3. Limitations and Future Research Directions*

Some constraints should also be recognized when drawing conclusions based on this study's findings. Data collection was carried out by a single team over a time span of four weeks, which should likely limit the results' generalizability to various tactical systems, methods of coaching, or levels of competition. Specific 1-4-4-2 diamond formation implementation used in this case also possibly influenced identified positional requirements, while other tactical approaches might yield different acceleration and deceleration patterns. Also, application of a rotational sampling technique under trainings, used for ensuring fair representation, will lead to individual disproportionate exposure to each microcycle's training stimulus. Lastly, individual player attributes, including their training history, history of injury, and current physical fitness, were not studied in this investigation; nevertheless, they have the potential to influence acceleration and deceleration performance patterns.

Future research investigations should widen their analytical lenses to include diverse groups utilizing various tactical systems and styles of play across extended periods. Such work would better enable the discovery of long-term position-specific and temporal patterns. Longitudinal investigations considered to examine associations between training and competition load differences and the development of injuries would have practical application to issues of poorly preparing for periods of deceleration. Studies that incorporate individual player attributes, including neuromuscular fatigue indicators and movement quality assessments, could further understand mechanisms affecting acceleration and deceleration abilities. Finally, intervention investigations conceived to examine adjusted training methods better emulating foundation competitive match demands are critical to developing evidence-based periodization methods bettering results while reducing professional soccer's injury risk.

## 5. Conclusions

This study provides comprehensive insights into the acceleration and deceleration demands of professional soccer across different match periods and playing positions. This is the first study to simultaneously examine both temporal microcycle variations and position-specific demands for acceleration and deceleration loads in the same professional cohort, revealing a critical training-competition mismatch in high-intensity deceleration zones. The analysis revealed that while total acceleration and deceleration loads remain relatively stable across match periods, the distribution and intensity of these demands vary significantly between playing positions, reflecting the tactical evolution of modern soccer. The findings demonstrate that cumulative acceleration and deceleration loads are substantial components of match demands, with players performing over 100 acceleration and deceleration actions per match across different intensity zones. Importantly, the quantified number and intensity of accelerations and decelerations could serve as potential injury indicators, given their association with neuromuscular fatigue and mechanical stress, particularly in high-intensity zones where training-match mismatches were observed. Our novel findings demonstrate pronounced position-specific deceleration profiles, with CM showing superior high-intensity engagement and FB elevated low-moderate intensity demands. The position-specific analysis revealed distinct profiles that align with contemporary tactical roles, challenging traditional assumptions about positional demands and highlighting the need for individualized training approaches that consider both the physiological and tactical requirements of each position within modern soccer systems, with particular emphasis on position-specific deceleration capabilities.

Coaches should implement position-specific training protocols reflecting the distinct demands identified: FB requiring high-volume, low-intensity work for dual defensive-offensive responsibilities; CM needing focused high-intensity deceleration training for congested spaces; and CD requiring preparation for sudden high-intensity actions in modern possession-based systems. Training periodization should maintain acceleration and deceleration capacities throughout the competitive season due to their stability across match periods, emphasizing regular neuromuscular preparation and volume work in lower intensity zones while ensuring adequate recovery to prevent overuse injuries. Additionally, monitoring the number and intensity of accelerations and decelerations throughout the season could provide valuable insights for injury prevention strategies, particularly when combined with position-specific load management approaches. When implementing tactical formations, coaches should consider varying mechanical demands on each position, providing adequate adaptation time and focusing on specific deceleration requirements through match simulation and tactical-physical integration approaches.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app15168936/s1, Table S1: Descriptive analysis of accelerations and decelerations based on match days and playing positions and overall values.

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**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

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