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The first, second, and third most demanding passages of play in professional soccer: a longitudinal study

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ABSTRACT: The study aimed to compare the physical demands required during the first, second, and third most demanding passages (MDP) of play considering the effect of playing position, type of passage, and passage duration. A longitudinal study for three mesocycles was conducted in a professional soccer team competing in *LaLiga123*. Tracking systems collected total distance covered (DIS), high-speed running distance (HSRD), sprinting distance (SPD), total of high-intensity accelerations (ACC_{HIGH}), and total of high-intensity decelerations (DEC_{HIGH}). The results confirmed that a significant effect of the type of passage (first, second or third MDP of play) on DIS ($F_{(1.24,\ 178.89)} = 115.53$; $p = 0.01$; $\eta p^2 = 0.45$), HSRD ($F_{(1.35,\ 195.36)} = 422.82$; $p = 0.01$; $\eta p^2 = 0.75$), SPD ($F_{(1.43,\ 206.59)} = 299.99$; $p = 0.01$; $\eta p^2 = 0.68$), ACC_{HIGH} ($F_{(1.45,\ 209.38)} = 268.59$; $p = 0.01$; $\eta p^2 = 0.65$), and DEC_{HIGH} ($F_{(1.45,\ 209.38)} = 324.88$; $p = 0.01$; $\eta p^2 = 0.69$) was found. In addition, a significant interaction between playing position, type and duration of the passage was observed in DIS ($F_{(12.60,\ 453.47)} = 1.98$; $p = 0.02$; $\eta p^2 = 0.05$) and ACC_{HIGH} ($F_{(13.99,\ 503.78)} = 1.92$; $p = 0.03$; $\eta p^2 = 0.06$). In conclusion, significant differences in physical demands between the first, second, and third MDP of play were observed. However, there were some cases (DIS and ACC_{HIGH}) in which no significant differences were found between these passages. Therefore, coaches should consider not only the magnitude of these peak intensity periods (e.g., distance covered per minute) but also the number of passages that players may experience during match play.

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INTRODUCTION

Soccer is characterized in its physical nature by an intermittent activity profile, mainly based on continuous changes of direction and speed (e.g., walking, jogging, high-speed running) [1–4]. This activity profile leads to the contribution of both aerobic and anaerobic energy systems, and hence its training is a determining factor in performance and injury prevention [5]. Many studies have reported that knowledge of the physical demands of competition is necessary to prescribe the optimum training load, especially in teams competing in leagues with uncongested schedules (i.e., one match per week) [6–8]. In this sense, previous studies have reported the average physical demands of competition to provide information to strength and conditioning coaches who may replicate the external load demands of competition in training [8, 9]. However, training tasks aimed at replicating average demands may underestimate match demands [10, 11].

Recent studies suggest that it is important to consider not only the general demands but also the peak demands that the player faces in certain phases of the match [10, 12]. These phases are known as the most demanding passages of play (MDP), which may also be referred to as worst-case scenarios [10, 13–15]. These MDP may be set at different durations (e.g., 1, 3, 5, 10 minutes) because a player may cover ~190 meters per minute given a 1-minute passage but a decrease to ~135 meters per minute is observed in 10-minute passages [10].

Currently, there is relatively little evidence published on the MDP in professional soccer. The investigations which are available within the literature show that: i) the MDP are specific periods in which the players are exposed to the greatest physical demands [10, 13, 14]; ii) positional differences exist in different variables of the MDP; iii) the longer the duration of the MDP, the lower the intensity [10, 12, 16, 17]; and, iv) differences may exist based on contextual variables such as match half [18].

However, from a practical perspective, it would be of interest to understand whether these MDP of play have any similarity to other highly demanding passages which may happen during official matches. To the best of the authors' knowledge, there are no investigations

available concerning this research question. Taking the first MDP as a reference of peak match demands may lead to misleading conclusions about the MDP of play. Hence, the analysis of successive passages in official matches is considered necessary in order to prescribe the training load considering the match's physical demands. Therefore, the aim of this study was to compare the physical demands required during the first, second, and third MDP of play in professional soccer matches considering the effect and interaction of playing position, type of passage, and passage duration.

MATERIALS AND METHODS

Study design

A longitudinal study for three mesocycles was conducted in a professional soccer team. A total of thirteen consecutive matches from *LaLiga 123* were registered. The research was conducted on a non-congested schedule which consisted of one match per week. The MDP of play were collected by electronic performance tracking systems (RealTrack Systems, Almeria, Spain) based on four passage durations (1, 3, 5 and 10 minutes) [10], type of passage (first, second and third) and playing position (central defender, CD: $n = 3$; full-back, FB: $n = 4$; midfielder, MF: $n = 4$; wide midfielder, WMF: $n = 4$; forward, FW: $n = 5$).

Participants

Data were collected from a total of 20 players (age: 26.8 ± 3.8 years old; body mass index: 23.1 ± 0.2) for thirteen consecutive matches. Full-match participation was considered as an inclusion criterion. However, goalkeepers were excluded from the study since this playing position has a different activity profile [19, 20]. Informed consent was obtained by the club in order to use the data of the participants once the season finished. This study was approved by the University of Almeria's Ethics Board.

Procedures

The physical demands of the MDP of play were analysed from the total distance covered (DIS), high-speed running distance (HSRD, above 19.8 km/h), sprinting distance (SPD, above 25.2 km/h), total of high-intensity accelerations (ACC_{HIGH}, above 3 m/s^2) and total of high-intensity decelerations (DEC_{HIGH}, below -3 m/s^2). These variables were reported in relation to the duration of the passage (i.e., per minute) and each passage was calculated using rolling averages. This procedure was established based on previous investigations on the MDP of play in professional soccer [10, 13].

These variables were reported at the end of each match by the software SPro (RealTrack Systems, Almería, Spain) since the data were collected using WIMU Pro (RealTrack Systems, Almería, Spain). These electronic performance tracking systems had Global Positioning Systems (GPS), which allowed the collection of the variables included in this study at 10 Hz sampling frequency. Furthermore, these systems are considered as valid (bias in mean velocity: 1.18–1.32 km/h; bias in distance: 2.32–4.32 m) and reliable (intraclass correlation coefficients: above 0.93) instruments for time-motion analysis in soccer [21]. Each player wore the same tracking system over the data collection period to avoid inter-unit error [10]. The tracking system was placed in a vertical position in the upper back pocket of a chest vest (Rasán, Valencia, Spain). The data were transferred to SPro software at the end of each match through Smart Station (RealTrack Systems, Almería, Spain). In addition, the number of satellites connected to the device was obtained from the SATCOUNT channel on SPro software (RealTrack Systems, Almería, Spain) in order to ensure that the data collection was carried out with an adequate connection in every match (Match 1: 7.88 ± 0.75 satellites; Match 2: 8.36 ± 0.93 satellites; Match 3: 7.48 ± 0.97 satellites; Match 4: 7.81 ± 0.59 satellites; Match 5: 8.09 ± 0.99 satellites; Match 6: 9.89 ± 0.72 satellites; Match 7: 8.41 ± 1.04 satellites; Match 8: 8.73 ± 1.49 satellites; Match 9: 9.01 ± 1.11 satellites; Match 10: 8.39 ± 0.73 satellites; Match 11: 8.69 ± 0.73 satellites; Match 12: 9.96 ± 0.87 satellites; Match 13: 10.89 ± 0.83 satellites) [22].

Statistical analysis

Descriptive statistics were calculated for all variables based on playing position and passages. The normality of data was evaluated using the Shapiro-Wilk test. Levene's test was used to assess the equality of variances while sphericity was assessed using Mauchly's test ($p < 0.05$ in all within-subjects variables). A linear model with a mixed-design analysis of variance (ANOVA) for repeated measures was analysed. DIS, HSRD, SPD, ACC_{HIGH} and DEC_{HIGH} were considered dependent variables. Duration (1, 3, 5 or 10 minutes) and type of passage (first, second or third MDP) were set as within-subjects variables while playing position was set as a between-subjects variable. The Bonferroni post hoc test was conducted for the comparison between types of passage. In addition, effect sizes were reported using partial eta-squared (ηp^2). The level of significance was set at alpha 0.05 ($p \leq 0.05$) and the statistical analysis was performed with SPSS Statistics for Windows version 25 (IBM Corp., Armonk, NY, USA).

RESULTS

Distance covered

Figure 1 shows the comparisons between the types of passage based on the duration of the passage and playing position. The type of passage had a significant effect on the DIS covered in the MDP of play ($F_{(1.24,\ 178.89)} = 115.53$; $p = 0.01$; $\eta p^2 = 0.45$). In addition, a significant interaction between playing position, type and duration of the passage was found for the DIS variable ($F_{(12.60,\ 453.47)} = 1.98$; $p = 0.02$; $\eta p^2 = 0.05$).

Although significant differences ($p < 0.05$) were found when comparing DIS covered between the types of passage in most MDP, this comparison was not significant in specific cases. For instance, Figure 1a shows that no significant differences were found between the first and second MDP in DIS covered by CD in 5-minute passages (mean difference: ~8.01 m; $p = 0.23$), and 10-minute passages

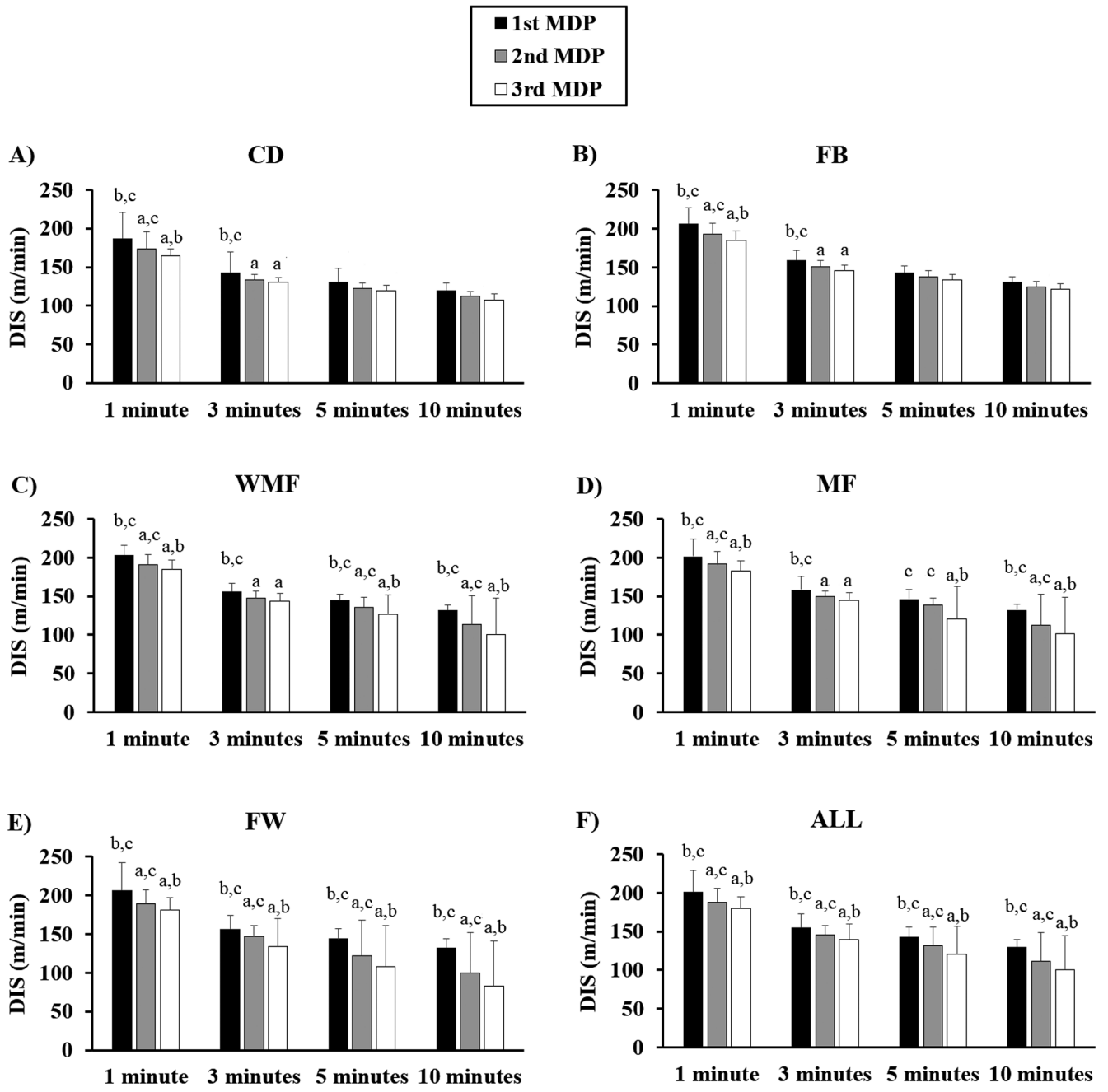

FIG. 1. Differences in distance covered (DIS) in meters per minute (m/min) between the first, second and third most demanding passages of play based on the duration of the passage (1, 3, 5 and 10 minutes) and playing position (CD, central defender in Figure 1a; FB, full-back in Figure 1b; WMF, wide-midfielder in Figure 1c; MF, midfielder in Figure 1d; FW, forward in Figure 1e; ALL, team in Figure 1f). Significant differences ($p < 0.05$) compared to the first (a), second (b), and third (c) MDP.

(mean difference: ~7.26 m; $p = 0.87$); between the first and third MDP in 5-minute passages (mean difference: ~10.78 m; $p = 0.32$), and 10-minute passages (mean difference: ~11.77 m; $p = 0.46$); and between the second and third MDP in 3-minute passages (mean difference: ~3.09 m; $p = 0.87$), 5-minute passages (mean difference: ~2.77 m; $p = 0.99$), and 10-minute passages (mean difference: 4.51 m; $p = 0.99$).

Figure 1b shows that no significant differences were found between the first and second MDP in DIS covered by FB in 5-minute passages (mean difference: ~4.73 m; $p = 0.88$) and 10-minute passages (mean difference: ~5.29 m; $p = 0.99$); between the first and third MDP in 5-minute passages (mean difference: ~8.89 m; $p = 0.55$) and 10-minute passages (mean difference: ~8.93 m; $p = 0.83$); and between the second and third MDP in 5-minute passages (mean difference: ~4.15 m; $p = 0.99$) and 10-minute passages (mean difference: ~3.63 m; $p = 0.99$).

Figure 1c shows that no significant differences were found between the second and third MDP in DIS covered by WMF in 3-minute

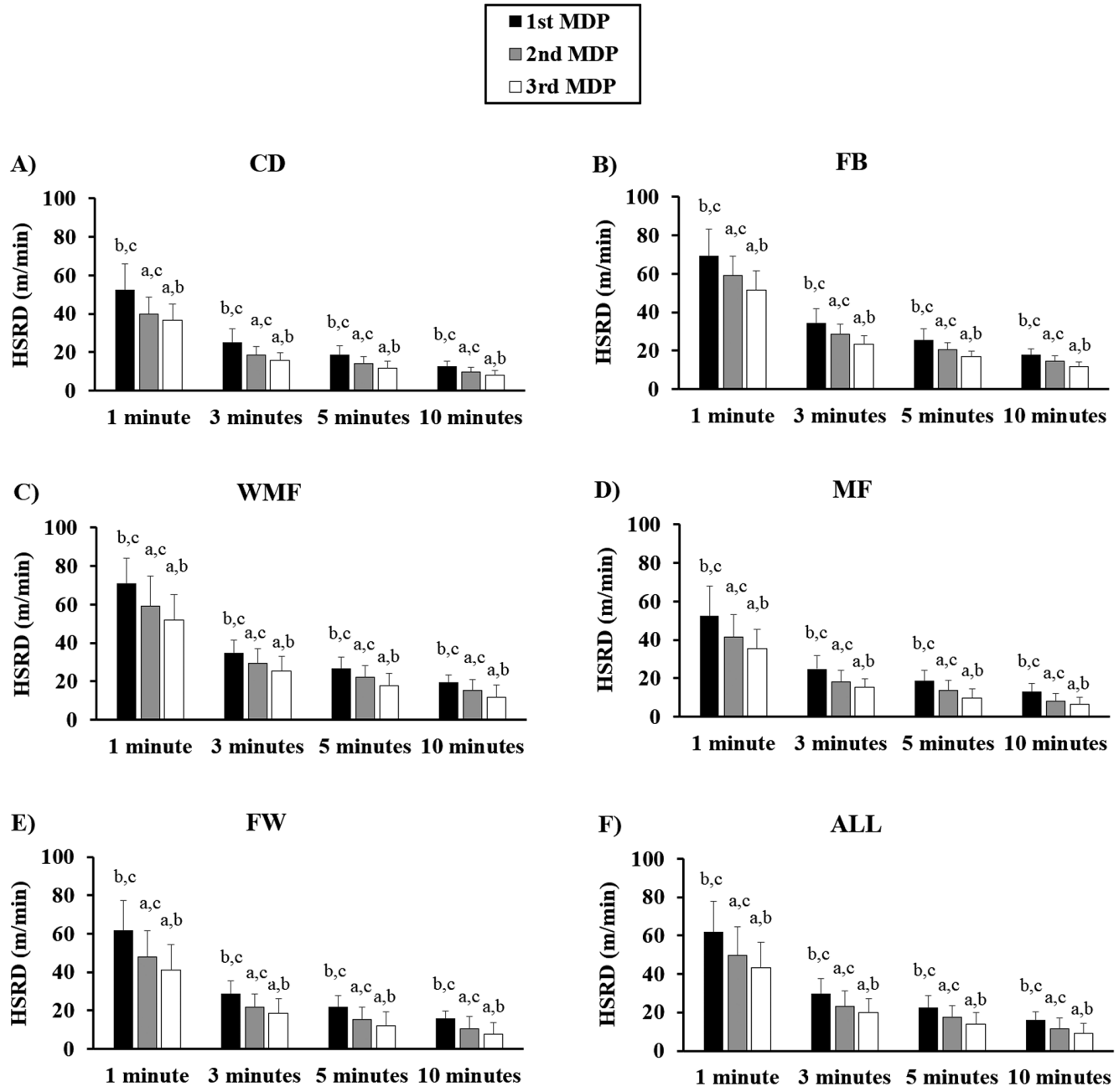

FIG. 2. Differences in high-speed running distance covered (HSRD) in meters per minute (m/min) between the first, second and third most demanding passages of play based on the duration of the passage (1, 3, 5 and 10 minutes) and playing position (CD, central defender in Figure 2a; FB, full-back in Figure 2b; WMF, wide-midfielder in Figure 2c; MF, midfielder in Figure 2d; FW, forward in Figure 2e; ALL, team in Figure 2f). Significant differences ($p < 0.05$) compared to the first (a), second (b), and third (c) MDP.

passages (mean difference: ~4.36 m; $p = 0.23$) and 5-minute passages (mean difference: ~8.57 m; $p = 0.13$).

Figure 1d shows that no significant differences were found between the first and second MDP in DIS covered by MF in 5-minute passages (mean difference: ~7.98 m; $p = 0.13$); and between the second and third MDP in 3-minute passages (mean difference: ~4.73 m; $p = 0.20$).

High-speed running distance covered

Regarding HSRD covered (Figure 2), the type of passage had a significant effect on the MDP of play ($F_{(1.35, 195.36)} = 422.82$; $p = 0.01$; $\eta p^2 = 0.75$). However, the interaction between playing position, type and duration of the passage was not significant for this variable ($F_{(9.69, 348.66)} = 0.64$; $p = 0.77$; $\eta p^2 = 0.02$). Figure 2 shows the comparisons between the types of passage, which were always significant ($p < 0.05$) based on the duration of the passage and playing position.

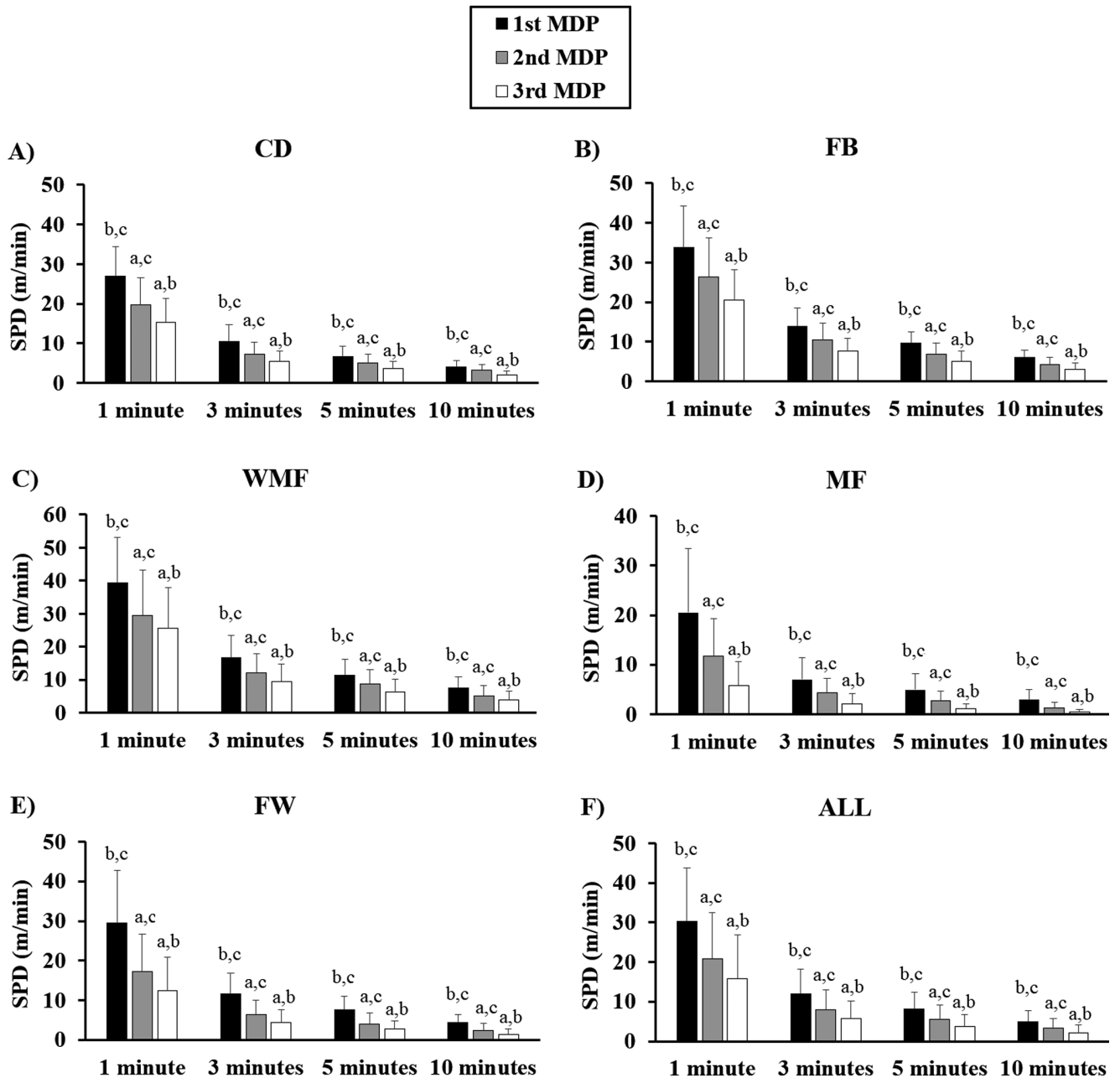

FIG. 3. Differences in sprinting distance covered (SPD) in meters per minute (m/min) between the first, second and third most demanding passages of play based on the duration of the passage (1, 3, 5 and 10 minutes) and playing position (CD, central defender in Figure 3a; FB, full-back in Figure 3b; WMF, wide-midfielder in Figure 3c; MF, midfielder in Figure 3d; FW, forward in Figure 3e; ALL, team in Figure 3f). Significant differences ($p < 0.05$) compared to the first (a), second (b), and third (c) MDP.

Sprinting distance covered

Figure 3 shows the descriptive statistics of SPD covered by the type of passage, playing position, and duration of the passage. In addition, the type of passage had a significant effect on the SPD covered in the MDP of play ($F_{(1.43, 206.59)} = 299.99$; $p = 0.01$; $\eta p^2 = 0.68$). Regarding the interaction between playing position, type and duration of the passage, it was not significant for SPD ($F_{(7.41, 266.71)} = 1.23$; $p = 0.28$; $\eta p^2 = 0.03$). However, the comparisons between the types of passage were always significant ($p < 0.05$) based on the duration of the passage and playing position (Figure 3).

Total of high-intensity accelerations

Regarding the total of ACC_{HIGH} (Figure 4), the type of passage had a significant effect on the MDP of play ($F_{(1.45, 209.38)} = 268.59$; $p = 0.01$; $\eta p^2 = 0.65$). In addition, there was a significant interaction between playing position, type and duration of the passage for ACC_{HIGH} ($F_{(13.99, 503.78)} = 1.92$; $p = 0.03$; $\eta p^2 = 0.06$). The

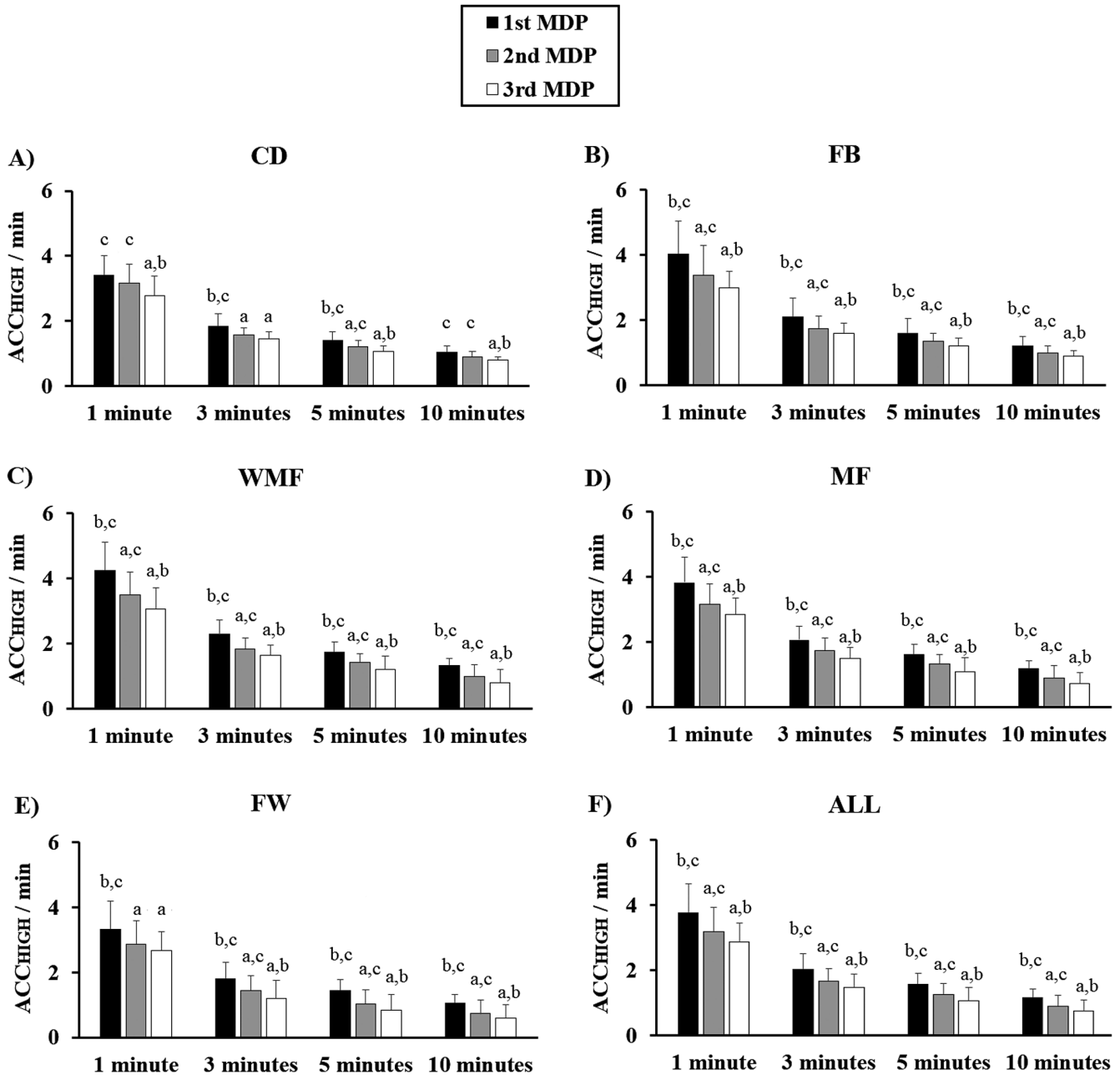

FIG. 4. Differences in the total of high-intensity accelerations (ACCHIGH) per minute between the first, second and third most demanding passages of play based on the duration of the passage (1, 3, 5 and 10 minutes) and playing position (CD, central defender in Figure 4a; FB, full-back in Figure 4b; WMF, wide-midfielder in Figure 4c; MF, midfielder in Figure 4d; FW, forward in Figure 4e; ALL, team in Figure 4f). Significant differences ($p < 0.05$) compared to the first (a), second (b), and third (c) MDP.

comparisons of ACC_{HIGH} between the types of passage were always significant ($p < 0.05$) based on the duration of the passage and playing position (Figure 4), except for the comparison between the first and second 1-minute passage in CD (mean difference: ~0.25; $p = 0.18$) and 10-minute passage (mean difference: ~0.14; $p = 0.11$); between the second and third 1-minute passage in FW (mean difference: ~0.19; $p = 0.12$) and 3-minute passage in CD (mean difference: ~0.11; $p = 0.07$).

Total of high-intensity decelerations

Finally, Figure 5 shows the descriptive statistics of DEC_{HIGH} by type of passage, playing position, and duration of the passage. The type of passage had a significant effect on the total of DEC_{HIGH} in the MDP of play ($F_{(1.45, 209.38)} = 324.88$; $p = 0.01$; $\eta p^2 = 0.69$). However, the interaction between playing position, type and duration of the passage was not significant in DEC_{HIGH} ($F_{(10.79, 388.55)} = 0.73$; $p = 0.28$; $\eta p^2 = 0.03$). Also, the comparisons between DEC_{HIGH} based on the type of passage were always significant ($p < 0.05$) based on the duration of the passage and playing position (Figure 5).

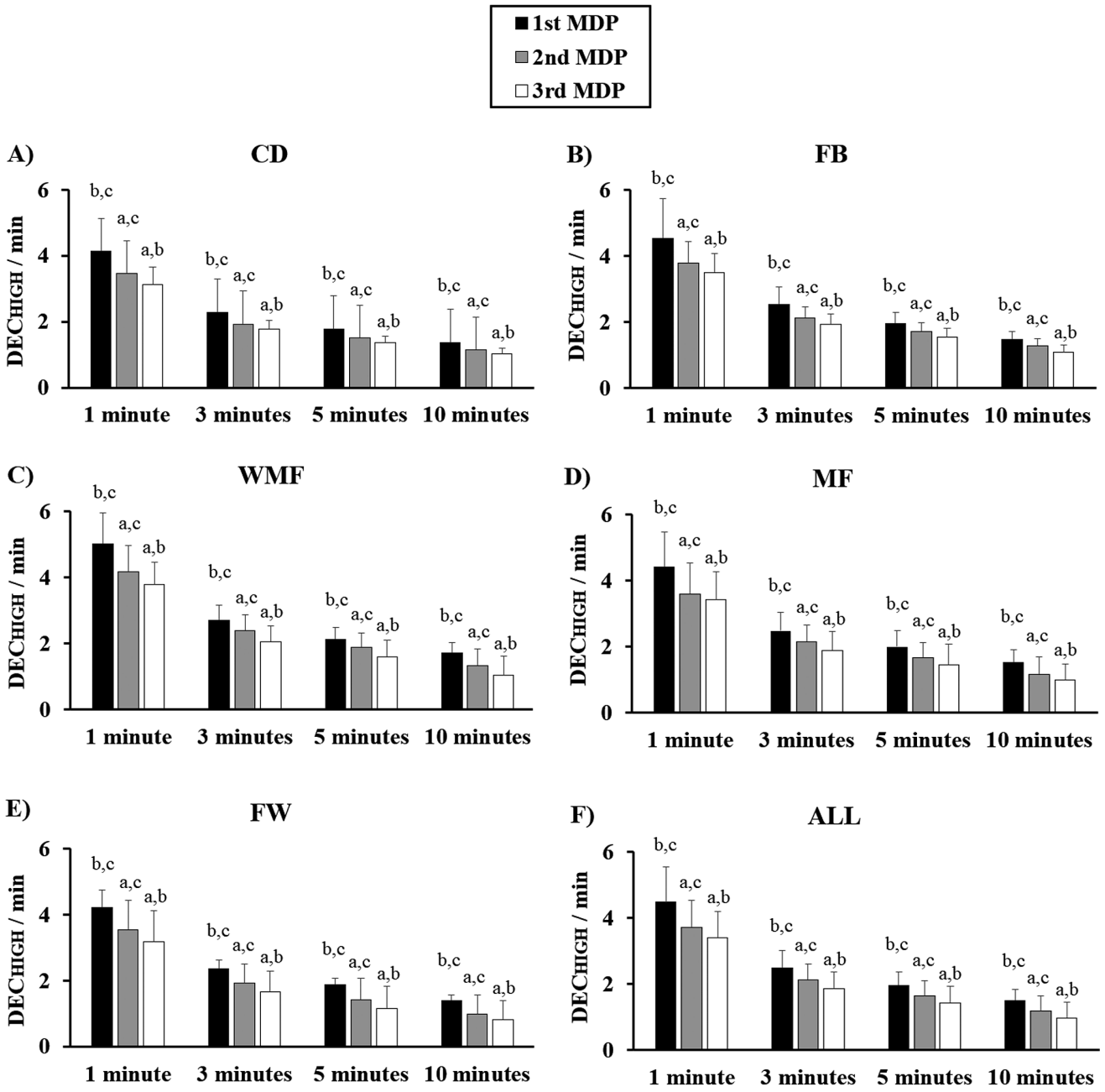

FIG. 5. Differences in the total of high-intensity decelerations (DECHIGH) per minute between the first, second and third most demanding passages of play based on the duration of the passage (1, 3, 5 and 10 minutes) and playing position (CD, central defender in Figure 5a; FB, full-back in Figure 5b; WMF, wide-midfielder in Figure 5c; MF, midfielder in Figure 5d; FW, forward in Figure 5e; ALL, team in Figure 5f). Significant differences ($p < 0.05$) compared to the first (a), second (b), and third (c) MDP.

DISCUSSION

To the best of the authors' knowledge, this was the first study to investigate whether there was any similarity between the first, second and third MDP of play in professional soccer matches. The aim of this study was to compare the physical demands required during the first, second, and third MDP of play considering the effect of playing position, type of passage, and passage duration. One of the main findings of the study was the observed significant effect of the type of passage on all the variables included in the study. The results confirmed that significant differences in physical demands existed between the first, second, and third MDP of play in all playing positions and passage durations. However, a further novel finding was that there were some cases (e.g., DIS and ACC_{HIGH}) in which no significant differences were found between these passages, which implies that coaches should consider not only the magnitude of the MDP but also the number of passages that players may experience in match play.

Although significant differences ($p < 0.05$) were found when comparing DIS covered between the types of passage in most MDP, this comparison was not significant in specific cases. For example,

FB and CD did not show any significant differences in DIS covered between passages for 5-minute and 10-minute MDP. This finding reveals that the first MDP cannot be considered as a 'unique' period in terms of intensity since the second and third passages are similar to the first one. This may be explained by the fact that the intensity in distance covered per minute decreases in longer passages [10, 12, 14, 16] because significant differences between the first, second, and third passages were always observed in 1 minute. In consequence, it is important to consider not only the magnitude (e.g., distance covered per minute) of the peak intensity periods [10, 12, 14, 23, 24] but also the amount of passages (i.e., the number of passages at peak intensity) when analysing the MDP of play. Specifically, defensive positions such as CD and FB need to be considered since the DIS covered in the first, second and third passages are similar.

Considering HSRD, a significant effect of the type of passage on the HSRD covered during the MDP of play was found and significant differences ($p < 0.05$) between the first, second, and third passages were observed in all playing positions and passage durations. This may be an important finding in the understanding of the MDP since the professional soccer players analysed in this investigation were unable to cover during second or third passages similar HSRD in comparison with the MDP of play. Since HSRD represents the distance covered above 19.8 km/h [10, 11], this high-speed threshold may explain why it is difficult to experience successive peak intensity periods. In this regard, future investigations should be designed in order to explain these results. For example, it would be of interest to analyse the inter-player variability in the MDP of play because a previous investigation found that the greater the speed threshold, the greater the variability [23], which means that there may be players experiencing second or third passages similar to the MDP.

Regarding SPD covered, similar findings to HSRD were found. The SPD covered was significantly different ($p < 0.05$) when comparing between the first, second, and third passages in all passage durations and playing positions. Although the speed threshold, which is set at 25.2 km/h for SPD [10, 11], may be a potential factor for decreasing the ability to reach a high-intensity period as mentioned above, it does not necessarily imply a relationship with physical fitness [25]. A previous study revealed that match contextual variables related to tactical or strategic requirements were likely to modulate on-field activity patterns (e.g., repeated-sprint activity) independently of the players' fitness [25]. Likewise, a recent study found that not all the training tasks (e.g., small-, medium- or large-sided games) were suitable to achieve the SPD from the MDP of play, which suggests that more research is necessary to understand what drills may be designed to train the MDP of play [13].

In addition, this study included an analysis of acceleration-based variables, whose results were in line with the distance-related variables. A significant effect on the total of ACC_{HIGH} in the MDP of play was found and differences were observed between the first, second, and third passages in most playing positions and passage durations. However, a further novel finding of this study was that no significant differences were observed for CD between the first and second 1-minute passage in CD (mean difference: ~0.25; $p = 0.18$), or between the second and third 1-minute passage in FW (mean difference: ~0.19; $p = 0.12$) or 3-minute passage in CD (mean difference: ~0.11; $p = 0.07$). Contrary to the findings of our study for DIS covered by CD and FB, in which no significant differences were observed in longer passages (i.e., 5 or 10 minutes), the variable ACC_{HIGH} did not show significant differences in shorter passages (i.e., 1 or 3 minutes). These results imply that strength and conditioning coaches need to consider the design of training tasks that stimulate the total of ACC_{HIGH} in short periods [10, 13]. However, these tasks should be aimed at reaching not only the ACC_{HIGH} of the MDP of play but also performing several passages (two or more, from one to three minutes). In this regard, a recent investigation reported an interesting practical implication for this variable, since it was observed that training tasks involving a smaller number of players elicited greater ACC_{HIGH} than others with more players [13]. For instance, small-sided games with five or six players may be a good strategy to adapt players for the MDP of play [13, 26].

Considering $DEC_{HIGH,}$ a significant effect of the type of passage was found on the total of DEC_{HIGH} in the MDP of play and significant differences were observed between the first, second, and third passages in all playing positions and passage durations. These results suggest that professional soccer players may experience several peak intensity periods with a high number of DEC_{HIGH}, but the intensity required in the first passage is significantly greater than the second MDP, which was also significantly more demanding than the third passage. Previous investigations on DEC_{HIGH} concluded that the damaging consequences of frequent and intense decelerations require specific loading strategies in order to mechanically protect the players from such consequences [7, 27]. DEC_{HIGH} usually last less than one second [7, 28] and require a high magnitude of mechanical load per meter [7, 29]. Since the mechanical load requires players to repeatedly suffer from high-intensity eccentric actions, the muscle damage and asymmetry in hamstring isometric strength increase [7, 30]. In consequence, future investigations may analyse whether the above-mentioned reasons, which are related to the neuromuscular fatigue of the player, explain why the DEC_{HIGH} from the first, second, and third MDP are significantly different.

However, this study has several limitations. Although each player wore the same tracking system over the data collection period to avoid inter-unit error [10], the data were collected with GPS technology [31, 32]. Then, the accuracy of variables such as ACC_{HIGH} and DEC_{HIGH} may be highly dependent on the devices used in this study [10] or the satellite connection from each match [22]. Future research may be conducted using local positioning systems which may increase the accuracy of the data [21]. Also, more variables (e.g., total of high-speed running actions or total of sprints) from the

MDP of play could be analysed since these represent the external load profile in professional soccer [4]. Also, absolute speed and acceleration thresholds were used for the calculation of HSRD, SPD, ACC_{HIGH}, and DEC_{HIGH}. In this regard, recent studies suggest that adding individualized thresholds (e.g., based on the player's maximal acceleration or sprinting speed) are advisable to detect individual differences [3, 33, 34].

The findings from this study have several practical applications for strength and conditioning coaches. For example, the magnitude of the MDP of match play from professional soccer players were provided based on playing position, which may serve as a reference for the design of training drills in order to adapt the players from each position to their specific competitive demands. Also, these training drills may be designed for different durations since the data were reported based on typical durations of the training drills (i.e., 1, 3, 5 and 10 minutes). Finally, the results imply that training drills should be designed considering not only the magnitude (e.g., distance covered per minute) of the MDP of play but also the successive passages (e.g., first, second, or third MDP) that players may experience in a match given the effect on the performance variables included in the study.

CONCLUSIONS

The results from this longitudinal study, which was conducted on professional soccer players for thirteen matches, confirmed that a significant effect of the type of passage (first, second or third MDP of play) was found on all the variables included in the study (DIS, HSRD, SPD, ACC_{HIGH}, DEC_{HIGH}). Significant differences in the physical demands were found between the first, second, and third MDP of play in all playing positions and passage durations. However, there were some cases (e.g., DIS and ACC_{HIGH}) in which no significant differences were found between the first, second, and third MDP of play.

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Conflict of Interest Disclosure

None of the authors has a conflict of interest to declare, and all authors were involved in the study design, data collection and interpretation, and contributed to the writing of the manuscript. This manuscript is original and not previously published, nor is it being considered elsewhere until a decision is made as to its acceptability by Biology of Sport.

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