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Section III – Sports and Physical Activity

To Ensure Peak Velocity in Soccer, Coaches Should Stimulate Players to Run

by
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The aim of this study was to compare the peak velocities reached by professional soccer players during multiple training tasks and friendly matches, taking into account players' positions. Global positioning system data were obtained from twenty-three soccer players (age: 24.8 ± 4.1 years; body height: 180.3 ± 6.3 cm; body mass: 75.7 ± 5.0 kg) who played for the same professional first division team of the Spanish league (La Liga). The peak of velocity (km·h^{-1}) of ten different training tasks was analyzed according to the players' position. The results showed that there were significant differences ($p < 0.05$) in the peak velocity reached by players in the different tasks studied: 1) velocity task (VE, n = 58) > tactical velocity task (TVE, n = 53), friendly match (FM, n = 231) > large-sided game (LSG, n = 146) > medium-sided game (MSG, n = 273) > evolution task (EVO, n = 381), high interval intensity training (HIIT, n = 227), small-sided game (SSG, n = 407) > large-sided ball-possession game (LSBPG, n = 227) > small-sided ball-possession game (SSBPG, n = 316) and, 2) that in the tasks with lower peak velocities (MSG, EVO, HIIT, SSG, LSBPG and SSBPG), no differences were found in their positions. Therefore, different training tasks create different peak velocity demands, and tasks with higher peak velocities and role-specificity (TVE, FM, LSG, and MSG) require different needs from players in different positions.

Keywords: *speed; GPS; peak intensity; football; small-sided games*

Introduction

From a conditional perspective, it is known that the primary challenge of the training process is to prepare soccer players to compete under optimal conditions (Gabbett et al., 2016). Preparation implies first knowing what the competition demands are and then trying to design training tasks that replicate or even surpass them (Martín-Garcia et al., 2019; Rabano-Muñoz et al., 2023), in order to prepare players for the most demanding scenarios of match play which will then have to be performed (Martín-García et al., 2018a, 2018b). The second step is to determine how to organize training tasks in a weekly micro-cycle (Douchet et al., 2024; Martín-García et al., 2018a, 2018b), considering both how much time has passed since the last match and to allow adequate post-match recovery for the next one, to avoid playing in a fatigued state (Ammann et al., 2023). This aspect could compromise performance in the following match (Grünbichler et al., 2019).

For some years, running at near maximum velocity has been a conditional aspect that has attracted attention in research (Haugen et al., 2019) in an attempt to help practitioners design training tasks for players (especially for those players who regularly participate in fewer official matches), targeting both performance enhancement and injury mitigation (Buchheit et al., 2020). There is increasing evidence in favour of replicating this match-specific conditional demand during the training week (Colby et al., 2018; Malone et al., 2017). Notably, neuromuscular activation differs

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when sprinting in the acceleration phase compared to approaching top speeds (Higashihara et al., 2018). The level of hamstring muscle activation is high, but submaximal speeds are higher than those achieved during maximal voluntary isometric contractions (Hegyi et al., 2019). Excessive exposure or lack of stimulation of this locomotor activity increases the player's risk of injury (Colby et al., 2018). Stimulating players in displacements where each player reaches speeds close to their maximum is therefore recommended, thereby reducing the probability of injury during sprints (Malone et al., 2017).

Although the comparison of the peak velocity achieved in different types of training tasks is not new (Casamichana and Castellano, 2010), a recent study (Kyprianou et al., 2019) concluded that peak velocity was higher for the sprint test when compared to matches and other skill-based conditioning drills. Notably, with larger dimensions of the pitch relative to each participant (m^2 per player) and absolute dimensions of the pitch (length x width), with particular reference to the distance between goals (Casamichana et al., 2018), the peak velocity reached by players increases (Casamichana and Castellano, 2010). In addition, as expected, players reach higher peak velocities in official matches than in small-sided games performed during training sessions (Casamichana et al., 2012) or training tasks (Asian-Clemente et al., 2025; de Dios-Álvarez, et al., 2025).

The differences in the average external demand (e.g., total distance covered) according to the playing position have been widely researched in literature (Bangsbo et al., 2006; Buchheit et al., 2020, 2023). More recently, the match's most demanding scenarios (e.g., relative distance and metres of sprinting) have been investigated, and the findings also show significant differences in playing positions (Martín-García et al., 2018a, 2018b). The players differ in their peak velocity in sprint tests and matches, depending on their position. For instance, flank players are generally faster than those in central roles (Al Haddad et al., 2015; Massard et al., 2018). However, the effect of the playing position on peak velocity during soccer-specific training sessions is unknown. This is relevant, as Buchheit et al. (2023) recently demonstrated that achieving near-maximal speed (95% of the individual's maximal sprinting speed) two days before a match, regardless of the turnaround length, results in a lower risk of match-related hamstring injury.

Accordingly, determining the peak velocity of each player during different training tasks is necessary to allow a training program within a typical soccer micro-cycle. Therefore, the primary objective of this study was to compare the peak velocities achieved by elite soccer players in different playing positions during various training tasks and friendly matches (FMs). The knowledge gained from this comparison will enable coaches to design and program their training process to work on relevant locomotor abilities while considering the role of each athlete, particularly on submaximal sprint training and injury risk reduction.

Methods

Participants

A total of twenty-three players playing for the same professional team participated in the study (age: 24.8 ± 4.1 years; body height: 180.3 ± 6.3 cm; body mass: 75.7 ± 5.0 kg) during the 2019–2020 in-season period of the first division Spanish league (La Liga). A total of 2088 training tasks and 231 FM records were accumulated (n = 2,319 individual activities). Players were categorized based on positional groups: wide defenders (WDs), central defenders (CDs), centre midfielders (CMs), offensive midfielders (OMs), wide midfielders (WMs), and forwards (FWs). The authorization of an institutional ethics committee was required (http://go.ehu.eus/C2TI0327), and this study was approved by the Ethics Committee (CEISH) of the University of the Basque Country (UPV/EHU), Vitoria-Gasteiz, Spain (protocol code: M10_2024_124; approval date: 21 May 2024). This study conformed to the Declaration of Helsinki, and the club permitted the release of the data with the anonymized identities of the players.

Design and Procedures

This study was conducted to determine the peak velocity achieved by professional players in various training tasks and functional movements (FMs), taking into account their playing position. The starting hypothesis was that different training tasks (with varying pitch dimensions, the number of players involved, and other specific rules) would require different peak velocities ($km \cdot h^{-1}$) from players in different positions. Furthermore, due to the roles of players in some of the training tasks, the peak velocity demand was not likely to be homogeneous in all positions. All the soccer players were familiar with the tasks and monitoring tools (GPS devices). Ten activities were analyzed (9 training tasks and FMs): 1) velocity task (VE) is a goal scoring task with a goalkeeper where the attacking player starts a few meters clear of the defender (eight training drills, 58 individual files); 2) tactical velocity task (TVE) is a tactical simulated situation where a defender loses possession and the attackers build a counter-attack on the goal, played on one half of the pitch (three training drills, 53 individual files); 3) large-sided games (LSGs) are training matches where two teams of 10 players + GK participate using pitch dimensions greater than 200 m^2 per player (nine training drills, 146 individual files); 4) medium-sided games (MSGs) are matches with two teams of 10 players + GK with less than 200 m^2 per player (16 training drills, 273 individual files); 5) evolution task (EVO) is a situation including 11 players vs. the opponent goalkeeper including shooting, where a sequence of passes and movements is previously set (25 training drills, 381 individual files); 6) HIIT is high-intensity interval training (32 training drills, 227 individual files); 7) SSG is a game where teams of six players or less + GK play in pitch dimensions close to 80 m^2 per player (26 training drills, 407 individual files); 8) large-sided ball-possession game (LSBPG) is a ball maintenance task where teams of more than seven players play with ~50 m^2 per player (14 training drills, 227 individual files), 9) small-sided ball-possession game (SSBPG) is a task where teams of less than seven players play with ~25 m^2 per player (23 training drills, 316 individual files); and 10) FMs are friendly matches where 15-min game periods were analyzed. Only players who completed all the match were included in the analysis (six FMs, 231 individual files).

Measurements

The peak velocity, which is a previously validated variable in team sports (Roe et al., 2016), was measured using portable GPS Vector model devices (Catapult Innovations, Melbourne, Australia). The devices were fixed on the upper back of players (interscapular zone) using a custom-made harness. The recordings that followed the ensuing signal-quality criteria were included for further analysis: average global navigation satellite system (GNSS) quality greater than 60% (the relative signal strength between the GPS Devices and the Global Navigation Satellite System (GNSS) for the selected Period/Activity(s) expressed as a percentage, with 100% being the strongest GPS lock possible) and horizontal dilution of precision (HDOP) less than 1. The data from the records used in the study achieved the GNSS quality of 67.4 ± 3.4%, HDOP of 0.78 ± 0.08, and an average connection of satellites of 12.0 ± 0.1.

Statistical Analysis

Descriptive statistics for the outcome measurements were calculated using means, standard deviations and confidence intervals at 95%. While the dependent variable was peak velocity, the independent variables were the ten training tasks (VE, TVE, FM, LSG, MSG, EVO, HIIT, SSG, LSBPG, and SSBPG) and the six playing positions (WD, CD, CM, OM, WM and FW). The Shapiro-Wilk test was implemented to assess the normality of the data distribution. The homogeneity of variance was examined by conducting the Levene's test, which was not complied with in all cases. A one-way ANOVA was used to evaluate differences in dependent variables throughout the tasks. Similarly, ANOVA was implemented for players' positions. In both, tasks and positions, a Dunn post-hoc test was applied due to the variances not being homogeneous. Cohen`s *d* effect size was used for pairwise comparisons. Thresholds for effect size (ES) statistics were <0.2, trivial; <0.6, small; <1.2, moderate; <2.0, large; and ≥2.0, very large (Hopkins et al., 2009). Statistical significance was established at $p < 0.05$. All data analyses were carried out using Excel and the statistical analysis software JASP version 0.16.1 (University of Amsterdam, https://jasp-stats.org/). The level of significance was set at $p < 0.05$.

Results

Figure 1 illustrates the mean, the standard deviation, and the 95% confidence interval of the peak velocities depending on the type of the task. The different tasks allowed the emergence of the players' peak velocities at distinct magnitude and with significant differences, such as: VE > TVE, FM > LSG > MSG > EVO, HIIT, SSG > LSBPG > SSBPG.

The magnitude of the differences was

moderate for VE vs. TVE (ES = 1.2) and vs. FM (ES = 1.1), and very large with the rest of the tasks: vs. LSG (ES = 1.8), vs. MSG (ES = 2.6), vs. EVO (ES = 2.3), vs. HIIT (ES = 5.2), vs. SSG (ES = 3.6), vs. LSBPG (ES = 4.6) and vs. SSBPG (ES = 4.9). Secondly, the magnitude of the differences was trivial for TVE vs. FM (ES = 0.1), small vs. LSG (ES = 0.6) and very large vs. MSG (ES = 1.3), EVO (ES = 1.5), HIIT (ES = 3.3), SSG (ES = 2.5), LSBPG (ES = 3.3), and SSBPG (ES = 3.8). Thirdly, the magnitude was small for FM vs. LSG (ES = 0.5), moderate for FM vs. MSG (ES = 1.1) and very large for FM vs. EVO (ES = 1.6), vs. HIIT (ES = 2.6), vs. SSG (ES = 2.3), vs. LSBPG (ES = 3.0), and vs. SSBPG (ES = 3.8). LSG had moderate magnitude when comparing with MSG (ES = 0.7) and EVO (ES = 1.2), and very large when compared with HIIT (ES = 2.3), SSG (ES = 2.0), LSBPG (ES = 2.7), and SSBPG (ES = 3.4). The magnitude of the differences was moderate for MSG vs. EVO (ES = 0.8) and very large vs. HIIT (ES = 1.5), SSG (ES = 1.4), LSBPG (ES = 2.1), and SSBPG (ES = 3.0). There was small magnitude of the difference for EVO vs. HIIT (ES = 0.2) and vs. SSG (ES = 0.3), moderate for EVO vs. LSBPG (ES = 0.7), and very large for EVO vs. SSBPG (ES = 1.6). The differences were trivial for HIIT vs. SSG (ES = 0.1), moderate for HIIT vs. LSBPG (ES = 0.9), very large for HIIT vs. SSBPG (ES = 1.9). Finally, the magnitude of the differences was moderate for SSG vs. LSBPG (ES = 0.6), very large for SSG vs. SSBPG (ES = 1.6), and moderate for LSBPG vs. SSBPG (ES = 1.1).

Figure 2 shows peak velocity for each training task (VE, TVE, FM, LSG, MSG, EVO, HIIT, SSG, LSBPG, and SSBPG) considering the player's position (CD, CM, FW, OM, WD, and WM).

The magnitude of the differences among training tasks and FMs regarding players' positions can be resumed in a main idea that when training tasks were more specific in roles of the playing position and/or more demanding in velocity (e.g., TVE, EVO, FM, LSG, and MSG), the differences among playing positions were higher; nevertheless, less demanding tasks did make a difference in players' position velocity peaks (e.g., HIIT, SSG, LSBPG, and SSBPG). In detail, the magnitude of the differences (Cohen's *d* and 95% CI, Lower/Upper values) for the tasks and positions that showed significant differences were as follows: in TVE for CMs vs. WDs: −2.6 (−4.9/−0.4); in FM for CMs vs. FWs: −1.7 (−3.0/−0.5), for CMs vs. WDs: −1.3 (−2.4/−0.2), for CMs vs. WMs: −1.6 (−2.7/−0.5), for FWs vs. OMs: 1.1 (0.1/2.2), for OMs vs. WMs: −1 (−1.9/−0.1); in LSG for CMs vs. WDs: −1.3 (−2.6/−0.04), for CMs vs. WMs: −1.4 (−2.7/−0.2); in MSG for CMs vs. WDs: −1.2 (−2.2/−0.3), for CMs vs. WMs: −1.2 (−2.1/−0.3); in EVO for CDs vs. CMs: 1.2 (0.4/2.0), for CDs vs. FWs: −1.0 (−1.8/−0.1), for CDs vs. OMs: −1.2 (−1.9/−0.5), for CDs vs. WDs: −1.9 (−2.7/−1.2), for CDs vs. WMs: −1.6 (−2.3/−0.9), for CMs vs. FWs: −2.1 (−3.1/−1.2), for CMs vs. OMs: −2.4 (−3.1/−1.6), for CMs vs. WDs: −3.1 (−3.9/−2.3), for CMs vs. WMs: −2.8 (−3.6/−2.0), for FWs vs. WDs: −1 (−1.8/−0.1), for OMs vs. WDs: −0.8 (−1.5/−0.1).

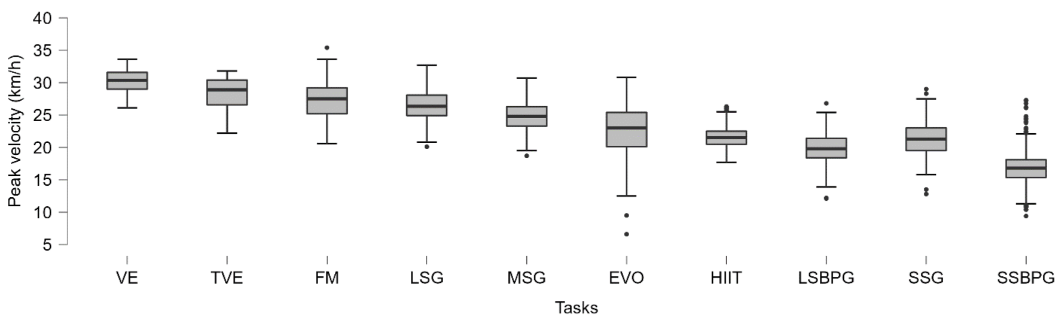

Figure 1. Peak velocity (km·h^{-1}) in different training tasks and friendly matches.
Note: VE is a velocity task, TVE is a tactical velocity task, FM is a friendly match, LSG is a large-sided game, MSG is a medium-sided game, EVO is an evolutions task, HIIT is high interval intensity training, SSG is a small-sided game, LSBPG is a large-sided ball-possession game, and SSBPG is a small-sided ball-possession game

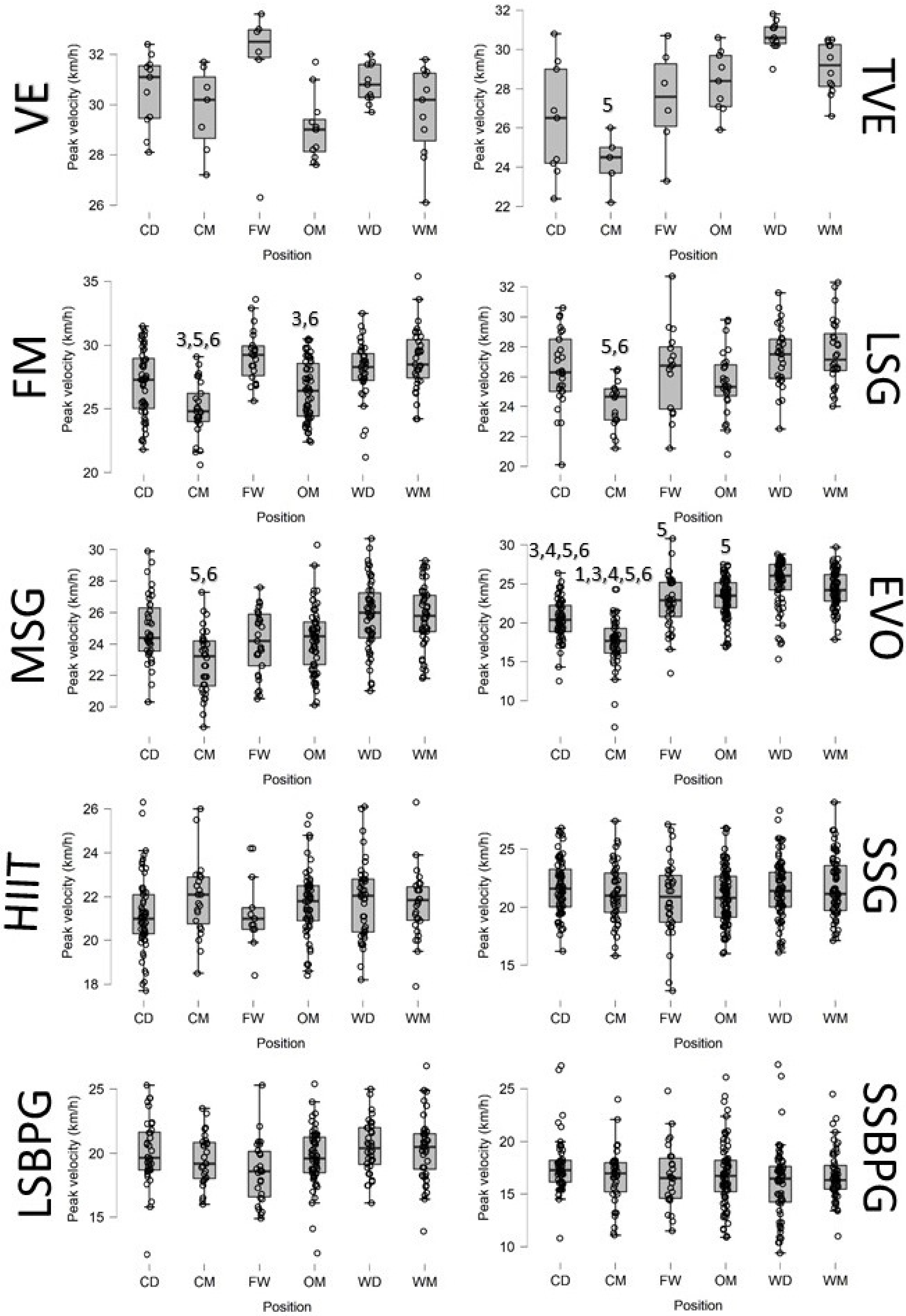

Figure 2. Peak velocity (km·h⁻¹) in different training tasks and friendly matches considering the playing position. A) VE is a velocity task, B) TVE is a tactical velocity task, C) FM is a friendly match, D) LSG is a large-sided game, E) MSG is a medium-sided game, F) EVO is an evolutions task, G) HIIT is high interval intensity training, H) SSG is a small-sided game, I) LSBPG is a large-sided ball-possession game, and J) SSBPG is a small-sided ball-possession game.

Note: CD is a central defender, CM is a central midfielder, FW is a forward, OM is an offensive midfielder, WD is a wide defender, and WM is a wide midfielder. 1 is <CD, 2 is <CM, 3 is <FW, 4 is <OM, 5 is <WD, and 6 is <WM

Discussion

The main objective of this study was to compare peak velocities reached by professional soccer players in various positions during a set of typical training tasks and in FMs. The main findings of this study reveal that not all the training tasks demanded the same peak velocity, and that there were intra-task differences in different playing positions. These differences were reduced in tasks where the requested peak velocity was lower or not role-specific to the players' positions.

A structured and systematic game development approach aims to integrate specific physical demands and patterns concerning match contexts (Jeffreys et al., 2018). Accordingly, the technical staff could use the current results to design a programme of training sessions, stimulating players in this conditional dimension (e.g., maximum velocity or peak velocity) while adjusting to the needs of the players' positions. A previous study demonstrated that sprint training can positively alter the architecture of the long head of the biceps femoris, increasing fascicle length and potentially mitigating injury while at the same time improving sprint mechanics and performance (Mendiguchia et al., 2020). Therefore, analyzing peak velocities in different training tasks and their distribution within a micro-cycle can be considered a promising road for applied research, focusing only on distances covered above arbitrary speed thresholds (Douchet et al., 2024; Sangnier et al., 2019).

Peak velocities reached in the VE and TVE tasks were significantly higher than peak velocities in other tasks. Tasks involving high numeric-superiority in relation to the opposition team (or opposition-free drills) may result in favourable conditions for reaching high-velocity peaks. The peculiarity of these tasks is that they are highly targeted (e.g., low complexity in the decision-making possibilities) and involve few players, allowing them to be focused on goal-scoring tasks (and consequently, high peak speed). Furthermore, these particular tasks could promote inter-session homogenous demands (Los Arcos et al., 2014). Nevertheless, between-position peak velocity variability may be higher during this type of the task, suggesting their use as a conditioning exercise when position-dependent tasks are recommended.

In the 15-min sections of the analyzed FMs, peak velocities reached values below those achieved in velocity tasks (VE and TVE). These results align with those obtained by Kyprianou et al. (2019) who found higher peak velocities in sprint exercises performed during training sessions than in matches. Furthermore, those authors found that during this type of speed exercise (sprints of between 5 and 40 m), players reached peak velocities that were only 3% lower than those obtained during the 40-m speed test (Kyprianou et al., 2019). In this sense, and despite a maximum speed test not being carried out, it can be assumed that the values achieved in this type of speed exercise (VE and TVE) will be very close to the maximum values that would have been obtained in the maximum speed test.

The group of following tasks: LSG, MSG, and EVO, was ranked second in terms of peak velocity demands (~27 km·h^{-1}). Whereas HIIT, SSG, and LSBPG tasks showed not-so-high peak velocity demands (~23 km·h^{-1}), and, finally, SSBPG was the task with the lowest peak velocity demands (~20 km·h^{-1}). In line with previous studies that analyzed the relative dimensions of the pitch during small-sided games (Asian-Clemente et al., 2025; Casamichana and Castellano, 2010; de Dios-Álvarez, et al., 2025; Kyprianou et al., 2019; Martin-Garcia et al., 2019), those with a greater relative pitch dimension per player were the ones that demanded higher peak velocities (LSG>MSG>SMG). A linear relationship between the relative pitch dimension of the game (m^2 per player) and the distance and the number of sprints was proven, and pitch dimensions of 280 m^2 per player were shown to reproduce the average intensity of a match (Clemente et al., 2023). In our study, in LSGs where the pitch dimension exceeded 200 m^2 per player, the peak velocity reached by players surpassed the most common fixed thresholds used for sprinting: 24.1 or 25.0 km·h^{-1} (Akenhead and Nassis, 2016; Anderson et al., 2016). Nonetheless, it must be acknowledged that, ideally, thresholds should be established according to individual maximal velocity abilities (Nakamura et al., 2017).

In addition to pitch dimensions, the presence of goals has also been shown to be a variable that modifies physiological and physical demands of soccer players in SSGs (Ammann and Chmura, 2023; Castellano et al., 2013). In the current study, tasks to keep ball possession (LSBPG and SSBPG) were the ones with the lowest peak speed reached by players. In addition, as shown in a previous study (Martín-García et al., 2020), the associated peak speed was also reduced when the pitch dimensions and the number of players were lower.

High-intensity interval training (HIIT) and evolution tasks (EVO) are proposed to simulate offensive and defensive game patterns, and they are similar to the rest of tasks that have moderate demands for peak velocity reached by soccer players. The absence of opposition in the latter implies that players do not need to reach peak velocity. Additionally, the prescribed HIIT does not involve game-specific situations, and players are aware of the pace beforehand. However, under specific HIIT configurations, these drills can indeed lead to a significant accumulation of high-speed running distances, as reported in previous research (Ammann and Chmura, 2023).

Except for the VE task, the CM position achieved the least peak velocity in all the tasks studied. The shooting speed task (VE) did not replicate the specific demands of the FM position. Furthermore, HIIT, SSG, LSBPG and SSBPG tasks did not differentiate between the demands on the peak velocity in particular playing positions, requiring similar absolute values ($km \cdot h^{-1}$) from different playing positions. On the other hand, it should also be noted that in FMs, LSGs, MSGs, and, specifically, EVOs, the same pattern was respected in peak velocity demands in the playing positions, with WM and WD positions achieving the highest values, followed by the CD and FW, thirdly OM, and finally CM positions that performed the task with the lowest value at peak velocity. EVO was the training task where most differences occurred in players' positions. Probably, both conditions — the analytic situation of the task and the role-specificity of the players' positions—could have been the reason for these differences.

This study presents some limitations that should be acknowledged. Although the chosen training tasks are representative of the content typically covered in professional soccer training sessions, the study sample only corresponds to a professional team and, therefore, to a specific game model and training dynamics. The second limitation of the study is that a maximum speed test was not performed, which would have allowed to determine the maximum value of each player. Future studies should explore teams that use "analytical" sprint training as part of their conditioning strategies to better understand how this exercise contributes to achieving peak velocities, as well as the frequency of these peak velocities since this training mode allows for repeating peak velocities during consecutive sprints.

The two main conclusions of the study are that not all tasks demand the same peak velocity from players and, as tasks demand higher peak velocity and role-specificity, more differences emerge in playing positions. The applications of these conclusions can be summarized as the need to quantify the peak velocity demands of training tasks, as not all of them transmit the same values. Secondly, when designing training tasks, it is necessary to consider the playing positions as they affect peak velocity and, consequently, the training stimulus. This should be considered when managing the workload and stimulating specific conditional dimensions to optimize performance, particularly for benched players and/or substitutes (e.g., when maintaining a stable sprinting load during the weekly microcycle), which helps to mitigate the risk of injury.

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