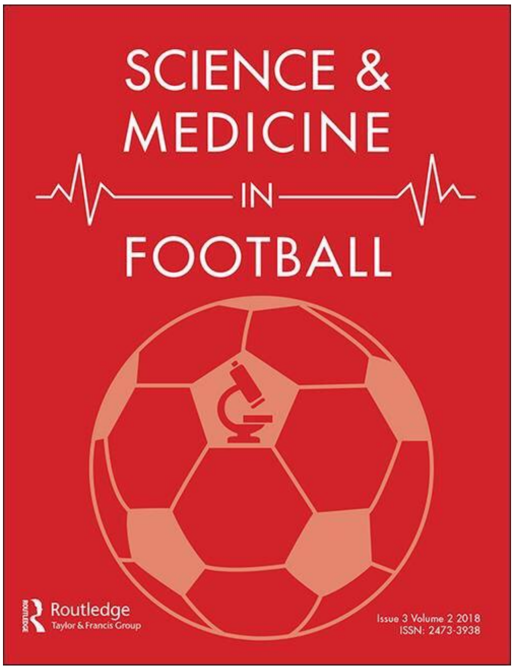

Title: Occurrences of near-to-maximal speed running bouts in elite soccer: insights for training prescription and injury mitigation

Submission type: original investigation

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Running Head: Maximal sprinting occurrence in elite soccer

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1. Abstract.

The aim of the present study was to quantify the occurrence of near-to-maximal speed running bouts in elite soccer players. Tracking match data from 35 elite professional players (23±3 yrs) were analysed over four seasons (2015-2019). The number of runs reaching >80, >85 and >90% of players' individual maximal sprinting speed (MSS) were computed. Potential differences in peak speed occurrences between halves and positions were analysed. The occurrences was not different between halves (trivial effect sizes), but slightly- to-moderately position-dependent, with wingers (3.5±2.0 runs >80%, 1.5±1.3 >85% and 0.5±0.7 >90% per half) and central midfielders (1.6±1.5 runs >80%, 0.7±1.0 >85% and 0.2±0.5 >90% per half) performing the most and the least number of near-to-maximal speed running bouts. Players did not reach >90% of MSS at all in 35% (Attackers) to 65% (Midfielders) of their matches; they reached ≥3 times >90% MSS per match in 2% (Midfielders) to 11% (Attackers) of their matches only. The maximal number of cumulated match occurrences during congested periods were observed in a central defender (~2 runs >90% of MSS every 4 days for 31 days, starting 8/8 matches) and a winger (1 run every 4 days for 52 days starting 13/14 matches). The occurrence of near-to-maximal speed running bouts is low in elite soccer. Match context, playing position and individual player profile are the main determinants of those occurrences. The present data can nevertheless help practitioners to design compensation sessions for substitutes, which should be useful in the context of both performance enhancement and injury mitigation.

Keywords: player monitoring; peak speed; sprinting; compensation; injury.

2. Intro

Hamstring strain injuries remain the most prevalent time loss injury in professional soccer.[1] While their relative occurrence may have slightly decreased in relation to the likely increased match demands over the past decade,[2] practitioners are still seeking for mitigation strategies both in the gym and on the pitch.[3] Among the different recommended strategies, the use of eccentric-biased exercises[4] and the management of high speed running[5] are likely the most effective and popular.[3] In relation to high-speed running management, while run-based high-intensity interval training can allow the accumulation of large amounts of distance in the range of 18-22 km/h,[6] it may not be fast enough to exert a profound protective effect on the hamstrings. For this reason, the implementation of maximal sprints (either with or without the ball) is also recommended.[7,8] Sprinting is indeed both complex and unique at many levels (e.g., leg interaction, elastic energy transfer, reflexes, kinematics, kinetics),[8] and a similar recruitment intensity of the hamstring muscles (i.e., electromyographic activity) can't be reached with isolated gym exercises.[9] Whether sprints need to be truly maximal to be protective in soccer players is still unclear, but some evidence suggests that reaching ≥90% of a player's own maximal sprinting speed (MSS) may be enough. In fact, stride length has been shown to be maximal at 90% [10], and training at 90% of MSS has led to similar performance outcomes to training at 100% in elite young soccer.[11,12]

Following this reasoning, recent studies have shown relationships between hamstring strain injuries and exposures to bouts of near-to-maximal speeds both in Australian Rules Football[13,14] and Gaelic Football[15] players. More precisely, both under- and over exposures to (close to) maximal speed runs were associated with the higher injury risk, suggesting the existence of an optimal chronic "dose" (i.e., number of weekly exposure[13,15] and/or monthly cumulative distance[14]). This optimal chronic dose is likely specific to each population and context, and it is therefore difficult to provide guidelines for all practitioners on the back of those two studies. A simple approach to define a chronic target in terms of locomotor load however is to use multiples of individual match loads.[3,16] For players likely to play 2 matches per week, maintaining a weekly chronic load equivalent to 2-3 times their typical match load prevents them -in theory- from presenting any spike,[3,16] irrespective of their match participation or not (post-match compensatory work[17]). While there has been a growing body of research to understand both match high-speed running[18,19] and top speed[20,21] demands in elite adult soccer players, almost all the information available is reported in terms of absolute loads (both distance accumulated within fixed high-speed speed bands and actual maximal speeds reached) without taking into consideration players' individual locomotor profiles (i.e., MSS).[22] As a matter of fact, it is impossible to know whether the speeds reached during those matches are fast enough (i.e., ≥90%) to be considered as "protective",[7,8] and how many of those near-to-maximal speed sprints should be performed when programming substitutes' workload.

In the only few studies to date examining match peak speed in relation to players' MSS (i.e., % of MSS reached),[23-25] only the relative speeds reached were reported; the detailed match occurrences of near-to-maximal speed running bouts were not reported. Considering the lack of information available in elite adult soccer players, we offer in the present paper a description of the match occurrence of >80%, >85% and >90% of MSS running bouts for the 4 main playing positions in a top professional team over 4 seasons. These data provide a theoretical framework for practitioners to apply within their own domains when it comes to managing exposure to near-to-maximal running bouts over the season.[3,17]

3. Methods.

Participants. The data from 35 professional players (23 ± 3 yrs, 182 ± 5 cm and 74 ± 4 kg) competing in the 1st French and European Champions Leagues were analysed (n = 1182 player match files, 34 ± 37 per players). These players participated on average in ~8 hours of soccer-specific training and competitive play per week (~2-3 sessions + 2 game per week), alongside almost daily core and lower-body prevention work (~30 min). The team played 90% of those matches using a 4-3-3 formation; ball possession was 64% ± 8 [range 29-80%]. These data arose as a condition of player monitoring in which player activities are routinely measured over the course of the competitive season;[26] therefore, ethics committee clearance was not required. The study conformed nevertheless to the recommendations of the Declaration of Helsinki.

Design. Observational, cross-sectional.

Methodology.

Player's MSS was defined as the highest running speed measured (augmented 18 Hz GPS, STATSports Apex, Newry, Ireland) during either 1) top-speed training sessions (i.e., 3-4 flying 20 to 30-m sprints; competition -duel- format) performed during the period of match analysis or 2) matches directly (6 players). Importantly, very fast players as those involved in the present study likely possess great acceleration capacities, which allows them to reach their MSS within short distances; this suggests that the competitive flying 20 to 30-m sprints used here may have been enough to determine MSS for the majority of them. Also, the peak speed reached during similar speed training sessions was shown to be similar to the maximal speed reached during proper speed testing.[24] Match tracking data were obtained with a semi-automatic system (STATSperfom, Nice, France[27]). All raw data were exported from the STATSports software (training) and STATSperform platform (match) to be reprocessed with the ADI analyser for calibration.[27,28] Two main variables were examined: 1) the number of cumulative runs reaching >80%, >85% and >90% of players' individual MSS and, 2) the cumulative distance above those three thresholds (D≥80%, D≥85% and D≥90%). Players were classified into four main positions (CD: central defenders, *n* = 8; WD: wide defenders, *n* = 7; MD: midfielders *n* = 9; and AT: attackers, *n* = 11). To illustrate the highest possible individual demands over short time periods, time blocks representative of three successive congested periods were examined. Congested periods included from 2 to 6 matches played successively within ≤4 days.[29]

Statistical Analysis.

Data in the text and figures are presented as means with standard deviations (SD) and 90% confidence limits/intervals (CL/CI). All data were first log-transformed to reduce bias arising from non-uniformity error. Between-halves and between-position differences in tracking data were examined using standardized differences, based on Cohen's effect size principle. While between-half differences were examined using full match data only, between-position differences were examined using first halves data only to increase sample size. Probabilities were used to make a qualitative probabilistic mechanistic inference about the true differences between the groups. The scale was as follows: 75−95%, likely; 95−99%, very likely; >99%, almost certain.[30]

4. Results.

Values for MSS were 34.4 ± 0.8, 34.3 ± 1.0, 33.9 ± 1.5 and 35.2 ± 0.9 km/h for CD, WD, CM and AT, respectively (all comparisons were unclear). The number of occurrences was not substantially different between halves (Table 1, trivial effect sizes), but slightly-to-moderately position-dependent (Figure 1), with wingers and central midfielders performing the most and the least numbers of near-to-maximal speed running bouts. The between-halves and between-position differences in the cumulated distance covered above those three individual speed thresholds followed exactly the same trends as the sprint occurrences.

The percentage of players reaching >80%, >85% and >90% of MSS during matches (1st half data) is presented in Table 2. Of interest, players did not reach ≥90% of MSS at all in 35% (AT) to 65% (MD) of their matches (Table 2); they reached ≥3 times ≥90% MSS per match in 2% (MD) to 11% (AT) of their matches only. There was also some large within-position variability in the occurrences, highlighting the impact of individual player profiles on those occurrences (e.g., 58% of matches without any occurrence ≥90% of MSS for CMs, but ranging from 15 to 86% depending on the player).

The maximal number of cumulative match occurrences during time blocks including successive congested periods were observed in an AT (winger, 11 runs over 52 days,~1 run (0.8 ± 1.2) every 4 days (4.0 ± 1.6) in average starting 13 of 14 matches) and a CD (18 runs >90% MSS over 31 days,~2 runs (2.3 ± 1.3) every 4 (4.4 ± 1.5) days in average, starting 8 of 8 matches) (Figure 2).

5. Discussion

In the present study we reported for the first time the occurrence of sprints reaching near-to-maximal speed in an elite soccer team. The results showed the occurrence to be low (i.e., 1 to 3 runs ≥90% MSS per match), not affected by time (all effect sizes were clearly trivial) but clearly by position (with up to moderate differences between CD and WD).

The lack of a time effect (Table 1) may contrast with the drop in high-speed running distance often observed during the second half (i.e., about -15%[19,31]). However, this decrease in running volume is often more related to a decreased effective time and other situational variables rather than to neuromuscular fatigue *per se*.[31] The fact that we emphasized here on the occurrences (and volume) of top speed runs only is therefore consistent with this latter hypothesis.[18] Players may decrease their overall activity toward the end of the game (e.g., lower relative playing time, pacing, less sprint repetitions) but may not lose their ability to reach high speeds during isolated runs – when/if required by the game. In practice, this means that when it comes to compensating near-to-peak velocity runs, the same reasoning may apply to bench (compensating a full match) and substitute players (compensating a portion of a match). In practice, for players likely to play 2 matches per week, maintaining a weekly chronic load equivalent to 2-3 times their typical match load prevents them in theory from presenting any spike,[3,16] irrespective of their match participation or not (post-match compensatory work[17]). Therefore, when compensating for a full match not played, a WD would for example need to perform about 6-8 runs >80% MSS, with 3 of them >85% and 1-2 >90% MSS (Table 1).

The between-position differences in the occurrence of near-to maximal speed sprints (Figure 1) confirm previous findings in elite young players[23-25] where the actual percentage of MSS reached was position-dependent. The specific roles and, more importantly, the running space available for each position is likely the most determinant factor of player's ability to reach high running speeds. In fact, the speed of a maximal running effort being directly related to its distance,[32] it's not surprising to see WD reaching more often higher speeds (both in absolute and relative terms) than MD or CDs. Interestingly also, there were some large differences in player's ability to reach top speeds (Table 2), and there were many matches during which players, irrespective their positions didn't even reach those speeds once. In fact, players did not reach >90% of MSS (at least during the first half) at all in 35% (AT) to 65% (MD) of their matches. This is consistent with the typical match-to-match variability in (high-speed) running demands,[33] but also confirms previous findings where some players (and especially some positions) were shown to never reach those top speeds. For example, in the study by Al Haddad,[23] CD, CM and 2d Strikers didn't reach 90% of their MSS (average match data). We also observed some important within-position differences (Table 2). Individual speed profiles (both acceleration capacity and MSS[34]) and playing styles may explain the differences in player's ability to reach high speeds even within a given position; this shows again the importance of individualizing speed work and compensation speed sessions.

Finally, we also presented two examples of repeated congested fixtures where players showed some large occurrences of >90% MSS running bouts for more than month (1-2 runs >90%MSS every 4 days in average, Figure 2). This realistic context, during which no compensation was required given the match repetitions, shows how important the conditioning of posterior chain muscle is to cope with these intensive match demands.[3]

An important limitation of the present study is the low number of players, and especially the number of players per position. Further studies are therefore required to confirm those findings in a greater number of players and/or other populations and teams.[19] Research should also examine the effect of playing formation[18] on the sprint occurrences reported. Longitudinal studies examining the impact of a systematic compensation of near-to-max velocity runs on sprint performance and injury risk are also still warranted.

6. Practical applications.

- The present data can be used to organise (positional) compensatory work for bench and substitute players, especially when it comes to maintaining a stable sprinting load across the weekly macrocycle.
- We suggest accumulating a weekly workload of 2-3 match loads to avoid any spike in loads for substitute players having to suddenly play twice a week. This chronic workload can be achieved via match exposures only (starters, Figure 2), match and compensation session (substitutes) or compensation sessions only (bench players).
- A typical full match top speed compensation session for a WD for example may be composed of 6-8 runs >80% MSS, with 3 of them >85% and 1-2 >90% MSS.
- Further than compensating for the number of near-to-maximal (linear) sprints, practitioners may also need to integrate specific sprint functions and patterns in relation to possible match contexts[35], i.e., attacking vs. defensive sprints including curved sprints and torso rotation; this may increase specificity both in terms of performance and injury mitigation.

7. Conclusions

The present results collected in an elite soccer team show that the occurrence of sprints reaching >90% MSS are low during matches (avg: 2 ± 2). While there were no differences between halves, CD and MD performed less maximal sprints than their AT counterparts, which is likely directly related to their roles and the space available to them when they play. The present data can help practitioners to design compensation sessions for substitutes, which should be useful in the context of both performance enhancement and injury mitigation. Further studies are nevertheless required to confirm those findings in other player populations and examine the effect of playing formation [18] on the occurrences reported.

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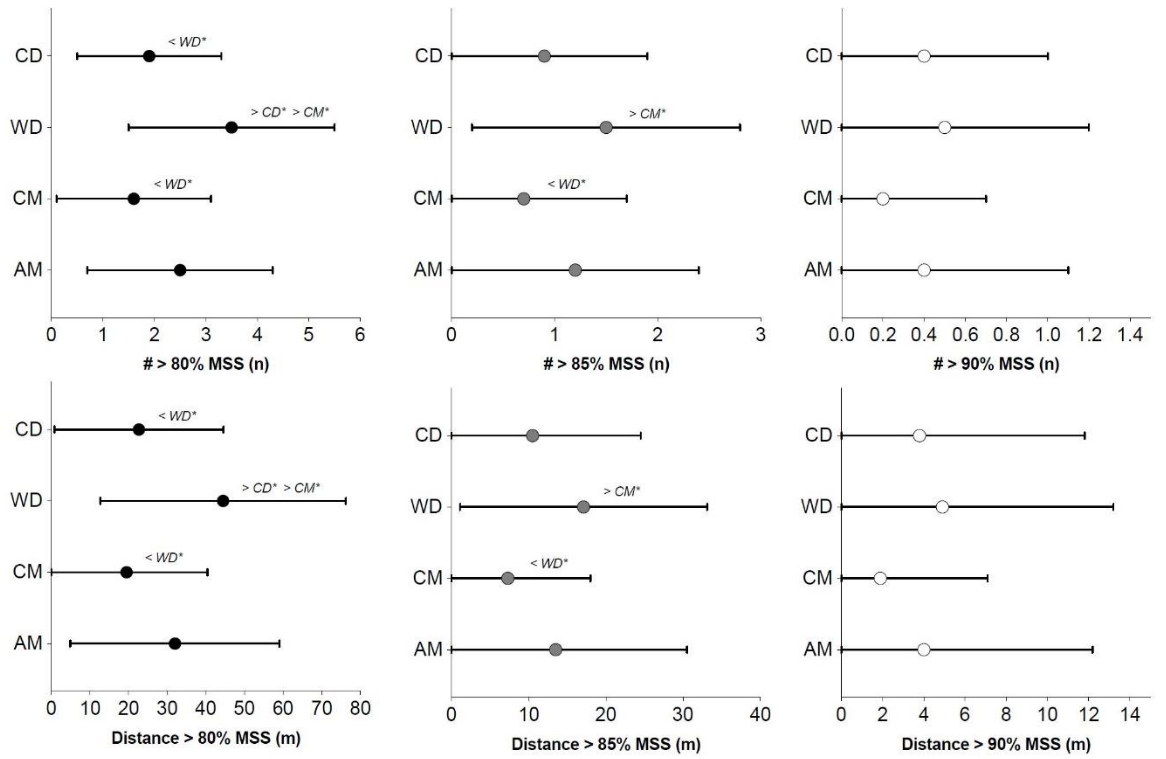

Figure 1. Number of occurrences of >80%, >85% and >90% MSS running bouts (upper panels), and cumulated distance run above those speed thresholds (lower panels) for the main four positions. Only first halves were used to increase sample size. CD: central defenders (n = 378), WD: wide defenders (n = 152), CM: central (n = 300) midfielders, AT: Attackers (n = 349). *: likely between-position differences. The direction of the differences is shown by the ‘>’ and ‘<’ signs. For example, ‘<WD*’ shown on the side of the CD value (upper left panel) means that CD presented likely lower occurrences than WD.

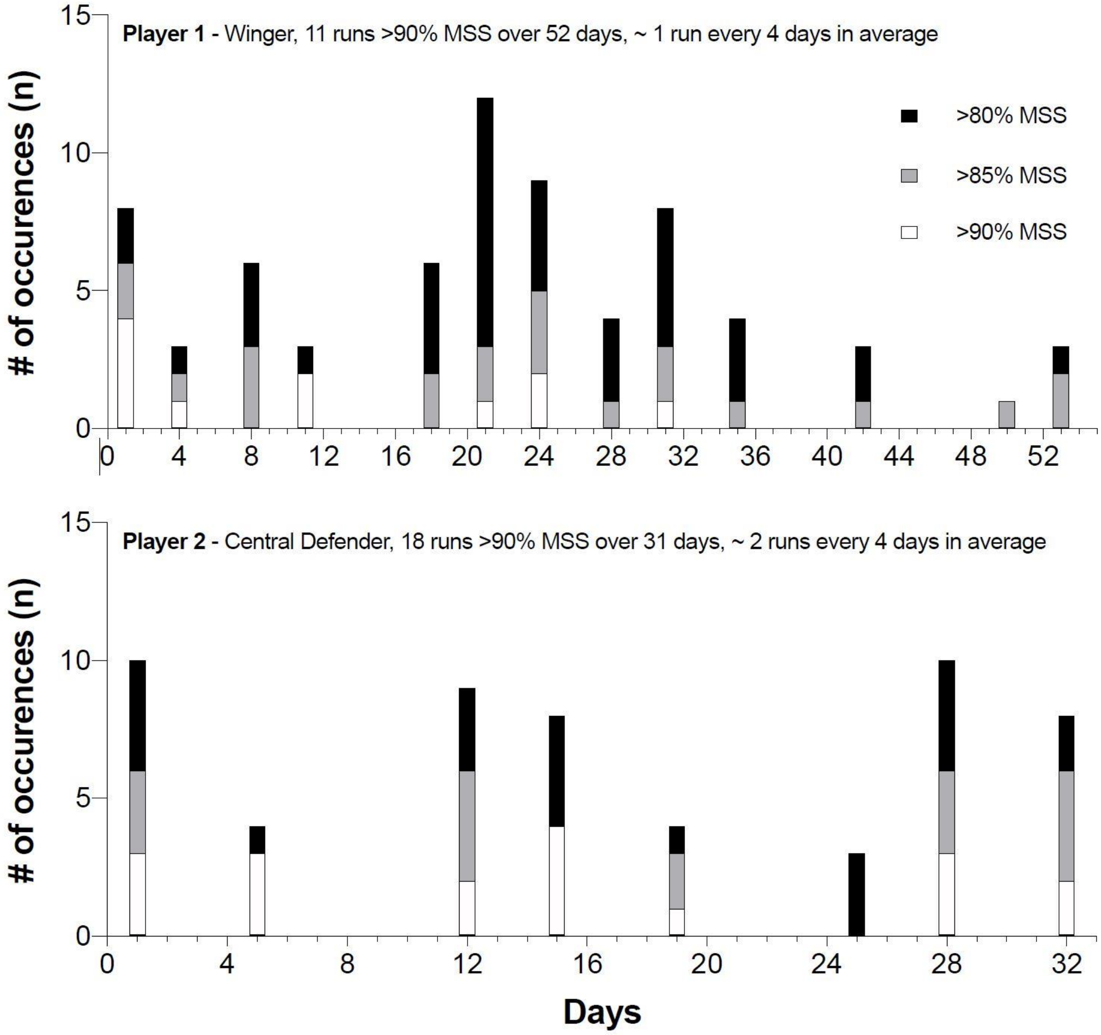

Figure 2. Examples of time blocks including three repeated congested periods (playing with ≤4 days between matches) showing the occurrence of >80%, >85% and >90% MSS running bouts in two representative players.