Implementing high-speed running and sprinting training in professional soccer

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Abstract

High-speed running and sprinting training play an important role in the development of physical capabilities, sport-specific performance and injury prevention among soccer players. This commentary aims to summarize the current evidence regarding high-speed running and sprinting training in professional soccer and to inform their implementation in research and applied settings. It is structured into four sections: 1) Evidence-based high-speed running and sprinting conditioning methodologies; 2) Monitoring of high-speed running and sprinting performance in soccer 3) Recommendations for effective implementation of high-speed running and sprinting training in applied soccer settings; 4) Limitations and future directions. The contemporary literature provides preliminary methodological guidelines for coaches and practitioners. The recommended methods to ensure high-speed running and sprinting exposure for both conditioning purposes and injury prevention strategies among soccer players are: high-intensity running training, field-based drills and ball-drills in the form of medium- and large-sided games. Global navigation satellite systems are valid and reliable technologies for high-speed running and sprinting monitoring practice. Future research is required to refine, and advance training practices aimed at optimizing individual high-speed running and sprinting training responses and associated long-term effects.

Keywords: GPS; Football; Performance; Team Sports

Introduction

Soccer is a physically demanding team sport with a locomotive intermittent profile characterized by high-intensity activities repeatedly performed throughout an entire match and interspersed with short low-intensity recovery periods [1]. Time-motion analyses of soccer matches report professional players to regularly cover total distances ranging between 10–13 km of which around 900 m and 250–300 m travelled at high-speed running (HSR; speed ranging from 19.8 $km \cdot h^{-1}$ to 25 $km \cdot h^{-1}$) and sprinting (speed $\geq$ 25 $km \cdot h^{-1}$), respectively [1,2]. Although HSR and sprinting account together for only 10% of the total distance covered during a match, the high intensity physical efforts they inherently involve are generally considered by researchers and practitioners of paramount importance for both competition outcomes and soccer specific fitness training [3,4,5]. Observational analyses of the locomotive demands during official soccer matches across the last ten years, have highlighted a consistent increase of HSR and sprinting efforts and relative distances by 24–35% and 36–63%, respectively [6,7]. In this background, straight sprinting has been identified as the single most frequent locomotive action in goal situations performed by either the scoring player and the assisting one [8]. Moreover, HSR and sprinting distances were also found to reduce towards the end of the game and temporarily after intense periods [1,9]. In particular, these periods coincide with the last 10-15 minutes of each half when higher frequency of goals are scored during a match [10]. On an individual level, the ability to repeatedly cope with the high-intensity demands of the match and to effectively execute their tactical role may ultimately represent an asset to gain advantages in attacking and defensive situations over the opponents [11]. In summary, it seems prudent to consider HSR and sprinting efforts as key determinant for successful participation in soccer both at team and individual level.

From a fitness training perspective, the cumulative effects of physical efforts involving maximal or submaximal accelerations nearly reaching maximal individual speeds can lead to high internal load responses and cause detrimental by-products as reflected by very high heart rates (mean heart rate > 85% of maximal heart rate), increased blood lactate concentrations, and residual fatigue effects [12,13,14]. Indeed, the physiological responses and the associated metabolic and mechanical adaptations induced by HSR and sprinting efforts presumably have a key role for long-term physical development and overall athletic performance of soccer players [15,16]. In particular, the mechanical loads induced by short accelerations (*e.g.* high force and power production), HSR and sprint efforts, are critical factors for sport-specific adaptations [17,18]. Therefore, HSR and sprinting distances should not be exclusively considered as surrogate parameters of aerobic and anaerobic-related performance, but also as adequate stimuli for neuromuscular adaptations, which could play a role in muscle injury prevention [11]. Recently, HSR and sprinting distances exposure have been reported as critical training load components that coaching staff and strength and conditioning practitioners should take into consideration and accurately manipulate with the aim to mitigate the likelihood of non-contact injuries [11]. In fact, whereas a well-planned and regular exposure to HSR, sprinting and high mechanical loads contribute optimizing physical development, large and rapid spikes of exposure to these efforts are associated to increased risk of injury [11]. Lower-limb muscle injuries and especially those affecting the hamstrings can cause massive performance and healthcare burdens among soccer payers [11,19,20,21]. Therefore, based on the growing evidence on the relationships between HSR and sprinting exposure and injury occurrence, practitioners should consider their accurate monitoring and implementations for injury prevention purposes [22].

Based on the scientific rationale and justification of HSR and sprinting training in soccer, this commentary aims to summarize the current evidence regarding HSR and sprinting training in professional soccer and to inform their evidence-based implementation in research and applied settings. It is structured into four sections: 1) Evidence-based HSR and sprinting conditioning methodologies; 2) Monitoring of high-speed running and sprinting performance in soccer 3) Recommendations for effective implementation of HSR and sprinting training in applied soccer settings; 4) Limitations and future directions.

Evidence-based HSR and sprinting conditioning methodologies in soccer

Considering the current evidence from soccer research, the capability to perform high-intensity efforts is a key physical prerequisite for successful participation [4,5,6]. Accordingly, coaches and practitioners should plan appropriate exposure to HSR and sprinting training among professional soccer players with the aim to either developing or maintaining their intermittent ability to perform high intensity efforts as frequently as required during competition [1,2]. In line with this paradigm, the most common methods of HSR and sprinting training documented in professional soccer are: high-intensity running training, field-based drills that replicates actions of the match play and ball-drills in the form of medium- and large-sided games [16,23,24,25]. Detailed information about the scientific rationale, methodological framework and practical applications of high-intensity running training for both individual and team-sport athletes can be found in the review article of Buchheit and Laursen [16]. Recent studies have used performance data in the form of the most intense match-play periods to configure soccer-specific high-intensity training drills [16,23,26,27,28,29]. Researchers have integrated movement patterns, technical skills, and tactical tasks to replicate the contextual demands of soccer. Apart from the inherent higher ecological validity associated to these training methodologies, they were also suggested as more effective for performing high-intensity short accelerations, decelerations and HSR efforts. Indeed, field-based drills are commonly performed in the form of fixed paths and dictated soccer-related activities, which ensure low intra-player and inter-player variability of the imposed training loads and intensities thus facilitating more consistent training responses and long-term effects [23,30,31]. Finally, these training approaches and all-out sprinting or repeated sprinting formats comprising linear sprint bouts of at least of 40 m length, can be confidently used to ensure HSR ($\geq$19.8 km·h^{-1}) and sprinting ($\geq$ 25 km·h^{-1}) exposure.

Generally, ball-drill protocols are demonstrated as a useful conditioning method to prepare players coping with the match demands [32,33]; however only few formats could be effectively implemented to develop HSR and sprinting capabilities [25,34]. Playing rules, playing area, number of players, players' density, inclusion or exclusion of goalkeepers and exercise:rest ratios are all key aspects to consider with the aim to induce specific locomotor demands and associated physiological responses [32,33,34,35]. In this context, efficient development and maintenance of HSR and sprinting capabilities can be attained by implementing the following game formats and associated designs:

a) 1vs1 or 2vs2 formats with mini goals (1.5 x 2 m) played in either long-narrow or long-wide pitches with a low player density ranging between 200-300 m^2 per player;

b) Repetitive bouts (4-8 games) of relative short duration (30-60”) and recovery (60-150”) to ensure an exercise:rest ratio ranging between 1:2 and 1:5;
c) Medium (7vs7 and 8vs8) and large-sided games (10vs10) of longer duration (>4 min) played on pitches with a player density around 300 m^2 per player allow to cover similar HSR distanced covered in a match.

Finally, the match itself should be weighted as a critical component of the training process [4]. The physical demands of the match have a key role for the overall load (*e.g.* volume and intensity) players are exposed to during a training micro-cycle. Moreover, it has been reported that the sole training sessions planned during a micro-cycle may fail to replicate the match equivalent HSR and sprinting load [4,22,34,36]. As a consequence, the lack of HSR and sprinting exposure and the missing adequate physiological stimuli, may likely preclude an effective soccer-specific conditioning process, particularly in non-starter players [22,36]. Therefore, soccer coaches should implement different training methods in the days following a match by considering individual players’ match time exposure (*e.g.* starters vs non-starters) for an effective management of HSR and sprinting training [36]. Alternatively, during congested fixture periods in which the available training time is limited, practitioners may consider to plan dedicated training sessions for non-starters immediately after the match conclusion when logistically feasible [22].

Monitoring HSR and sprinting performance in soccer

The main purpose of this section is to raise awareness about key methodological aspects for a correct and informed use of HSR and sprinting metrics in applied settings [37,38]. The monitoring of HSR and sprinting performance in soccer is regularly conducted using global navigation satellite systems (GNSS), local positioning systems, and optical tracking systems [37,38]. These systems extrapolate external load parameters like displacement and velocity metrics over time with HSR and sprinting analysis based upon the quantification of distances and relative time spent within speed zones or ranges defined according to arbitrary threshold values or percentages relative to individual players’ maximal speeds reached during either testing sessions or matches [38,39]. Specifically, GNSS systems are sufficiently accurate to monitor distances during both high-intensity linear and sport-specific activities [37,40]. Therefore, GNSS-based metrics are confidently used to make daily informed decisions guiding coaching processes aimed at optimizing physical and physiological adaptations [37].

In this context, a few considerations should be made for correct HSR and sprinting monitoring practices in soccer:

Firstly, the accuracy and variability of HSR and sprinting measures can be reduced by the specific nature of the performed activities. In particular, while HSR and sprint distances covered along fixed linear or slightly curvilinear locomotor paths can be confidently quantified [38,41], game-based conditioning methods such as small-sided games and possession drills, including frequent accelerations, decelerations, and changes of direction activities, may reduce the accuracy of external load parameters quantification. Nevertheless, accuracy and reliability levels of GNSS-based metrics, in particular using recently validated technologies, fall within acceptable ranges, which supports their use to inform training planning and design practices [28,42,43].

Secondly, consensus on HSR and sprinting velocity thresholds in soccer is still under debate with consequent discrepancies [44,45,46,47]. A rigorous evaluation of studies solely conducted with professional soccer players suggests interpreting activities ≥ 15 km·h^{-1} or ≥ 19.8 km·h^{-1} as HSR, and ≥ 25.2 km·h^{-1} as sprinting, respectively. These fixed speed ranges are suitable for an overall quantification of the HSR and sprinting loads [22], while their implementation as references for a sensitive analysis of the individual exposure is still arguable. In fact, the use of general thresholds presumes that the same exact physiological responses and training effects are induced on players covering comparable HSR and sprinting distances without accounting for their individual characteristics and fitness status. This approach may result in overestimated HSR exposure for some, or underestimation for others [44]. Accordingly, a very recent study suggested the importance of individualizing speed running thresholds (*e.g.* > 80% of player's peak speed) to optimize soccer external load analysis [22]. However, further research is needed to verify the practical validity of this approach because individual thresholds may introduce complexity in data interpretation, and could reduce the possibility and cost-effectiveness in comparing training loads between players and training sessions.

Thirdly, absolute measures of distance covered, HSR, and sprinting should be analyzed as either fixed or rolling split times – namely epochs – of 1 min duration in order to accurately capture the peak physical demands of match-play and training sessions [3]. Epochs of longer durations provide an overall quantification of intensity, but their use may result in cutting-off and underestimating peak physical efforts with the consequent likely misinterpretation of the training stimuli and the associated responses.

For a further understanding of the procedural related limitations GNSS technology and training load monitoring the reader is referred to the following papers [37,48,49,50].

Recommendations for effective implementation of HSR and sprinting training in applied soccer settings

In light of the scientific background and the contemporary literature the following evidence-based recommendations can be provided.

a) Tracking systems and GNSS can be used to monitor HSR and sprinting exposure based on fixed or individualized speed thresholds;
b) A realistic quantification of an individual player's peak speed should be determined from either official matches outcomes or 30-40 m maximal linear sprint efforts (or flying sprints) implemented as testing routine;
c) Short sprinting distances (< 30 m) can be used to develop acceleration capabilities, but they are not suitable for sprinting exposure (distance covered at speed ≥ 25 $km \cdot h^{-1}$);
d) Medium and large sided-game formats can be used to ensure HSR and sprinting exposure likely inducing the desired responses and adaptations underpinning development and maintenance of high-intensity capabilities;
e) Field-based drills and sprint training may be preferable alternative methods due to their predictable HSR and sprinting exposure and to the reduced players' responses variability;
f) Periodization of HSR and sprinting training should be based on starting status (*e.g.* starters and non-starters) and match position demands in order to optimize recovery and performance peaking for match-day;
g) Sprinting training may mitigate the likelihood of lower limb muscles (*e.g.* hamstrings) injuries by exposing players to the mechanical loads and characteristics muscle actions required during the terminal swing phase of the sprinting gait.

Limitations and future directions

From the existing literature the following limitations and future research questions emerge:

a) Further research is needed to investigate any advantage associated with the use of individualized speed thresholds determined from a players' peak speed compared to general thresholds;

b) Further research is needed to define how to optimally design ball-drill protocols (*e.g.* large sided-games) pitch sizes ensuring HSR and sprinting exposure;
c) Periodization guidelines should be produced to inform the design of critical variables for HSR and sprinting training such as volume, frequency, density, and timing during the different phases of a soccer season and the respective weekly micro-cycles;
d) Limited evidence exists about the management of HSR and sprinting training during the weekly micro-cycle between starter and non-starter players;
e) Further studies need to investigate the relationships between sprinting exposure and muscle injuries (*e.g.* hamstrings) thus guiding informed training prescription contributing to mitigate their occurrence.

Conclusions

Both HSR and sprinting training play an important role for the development of physical capabilities, sport-specific performance, and injury prevention among soccer players. This commentary summarized the scientific rationale, monitoring evidences and practical recommendations for HSR and sprinting training in professional soccer. The contemporary literature provides preliminary methodological guidelines for coaches and practitioners. Future research is required to refine and to advance training practices aimed at optimizing individual HSR and sprinting training responses and effects.

Conflict of interest

All other authors declare no competing interests. Authors confirm that this study meets the ethical standards of the journal [51].

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