Title: Profiling the responses of soccer substitutes: A review of current literature

Running Head: The responses of soccer substitutes

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Abstract word count: 248

Manuscript word count: 5995

Tables: 3

Figures: 1

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## ABSTRACT

Depending upon competition regulations, the laws of soccer allow between three and an unlimited number of substitutions that can be made on either a permanent or rolling basis. Substitutes are typically introduced to minimise/offset the effects of fatigue, alter tactics, replace players deemed as underperforming or injured, and/or give playing time to youth players, or to squad members returning from injury. While the match-day practices of substitutes include participation in the pre-match warm-up, and sporadic periods of rewarm-up activity, it is currently unclear as to whether these pre-entry preparations facilitate optimal match performance thereafter. Acknowledging the contextual factors that possibly influence substitutes' performance, this review summarises the presently available literature on soccer substitutes, and makes recommendations for future research. Literature searching and screening yielded thirteen studies, which have typically focused on characterising 1) the patterns, including timing, of substitutes' introduction; 2) indices of match-performance; and 3) the emotional experiences of soccer substitutes. The majority of substitutions occur after the first-half has ended (i.e., at half-time or during the second-half), with introduced players exceeding the second-half physical performances of those who started the match. Observations of progressive improvements in running performance as playing time increases, and findings that substitutes mostly experience negative emotions, highlight the potential inadequacies of pre-match preparations, and present future research opportunities. Additional work is therefore needed to confirm these findings and to determine the efficacy of current preparation strategies, thereby providing opportunities to assess then address substitutes' pre-pitch entry preparations, on-field performance, and emotional responses.

## KEY POINTS

- Soccer substitutes are typically introduced at half-time or during the second half, usually in an attempt to offset the effects of fatigue and/or alter tactics, although other motivations can exist.
- Substitutes, particularly midfielders, appear able to exceed the work-rates of players who started the match; however, their overall contributions to team success remain to be determined.
- Empirical observations of pre pitch-entry practices, players' own concerns, and the inability of players introduced later into a match to exceed their own habitual work-rate when starting, question the efficacy of substitutes' physical and psychological preparations.

## 1.0 INTRODUCTION

Soccer is an intermittent sport, typically contested between two teams of eleven players, over 45 min halves separated by an interval of ~15 min (half-time). Although low-intensity activities dominate [1-3], a player's ability to repeatedly perform high-intensity actions is a characteristic of professional soccer [4]. Amongst the most robust observations existing in soccer literature are the declines in indices of both physical (e.g., high-intensity running; HIR) and technical (e.g., shooting and passing skills such as speed, accuracy, success etc.) performances that occur transiently and progressively over the course of 90 min [4-12], responses which seem exacerbated in matches requiring extra-time [8, 13-16]. A variety of fatigue-mechanisms, both central and peripheral in origin, have been proposed to explain these changes, although the causes of such responses are likely multifactorial [1, 17-21].

In order to minimise/offset the effects of fatigue, soccer coaches and managers can introduce substitute players into a game, although these introductions may also reflect tactical changes, decisions to replace underperforming or injured players [21, 22], and/or to satisfy a need for game-time in youth players or those returning from injury. Fédération Internationale de Football Association (FIFA) rules first included reference to substitutions in 1958 and currently permit a maximum of three starting players (up to six in some competitions) to be irreversibly replaced from a 'bench' of typically six (up to 12 in some competitions) substitutes [23]. Whilst FIFA govern the majority of competitions worldwide, an unlimited number of 'rolling' interchanges are permitted during the second-half of National Collegiate Athletic Association (NCAA) competitions, whereby players may re-enter the pitch having previously been replaced [24, 25]. Whilst increasing physical output does not guarantee success [5, 26], Bradley et al. [22] highlight that for substitutes to be deemed effective from a work-rate perspective, the players introduced must be immediately able to perform at equivalent or higher work-rates than the players being replaced, and/or others remaining on the pitch. Surprisingly however, while the movement demands of whole-match soccer players has been extensively investigated [1-5, 27-32], fewer data exist regarding the responses of substitutes entering the field of play.

Acknowledging that considerable variation may exist between clubs, empirical observations highlight commonalities in substitutes' match-day routines (Figure 1). Although they may perform lower-intensity activities, substitutes typically warm-up alongside the starting eleven prior to kick-off, before spending the majority of the first-half seated pitch-side. After kick-off, sporadic rewarm-up activity will typically take place between the halfway line and the corner flag. Whilst regulations differ in some competitions, the English

Football League does not permit coaches to leave the 'technical area' whilst play is underway, therefore the content and intensity of rewarm-ups is mostly player-led. The expectation is that (failing injury) replacements will enter the match at half-time or later, therefore substitutes typically perform further half-time activity on the pitch before increasing the frequency and/or intensity of rewarm-ups during the second-half, in anticipation of pitch-entry. Notwithstanding the broadly similar rewarm-up patterns existing across matches, empirical observations suggest that on-pitch events (in particular, the proximity of play to the awaiting substitutes) heavily influence the type and/or intensity of rewarm-up activity performed. Given the limited literature available, this narrative review aims to summarise the findings of existing publications which profile the responses of soccer substitutes, with a view to informing practice and highlighting opportunities for future research.

****INSERT FIGURE 1 HERE****

**2.0 METHODOLOGY**

Searches were performed in four online databases (i.e., PubMed, SPORTDiscus, Google Scholar, and ScienceDirect) during February 2018, and included articles published until this time. Keywords relating to the sport (i.e., 'soccer', 'football'), and different terms for player substitution (i.e., 'substitute', 'substituted', 'substitution', 'finisher', 'replacement', 'replaced', 'bench'), were entered in various combinations. Filters included: Original publications in scientific journals, with English full-texts available. Titles were initially scanned, and potentially relevant articles were retrieved. After removing duplicates and papers excluded upon screening of the abstract, the remaining full-texts were assessed. Articles were excluded on the basis that they: A) were review articles, B) did not concern soccer specifically, or C) considered 'non-starters' *generally,* as opposed to substitutes. While the terms 'substitutes' and 'non-starters' may appear the same, 'non-starters' implies all members of a squad except for the starting eleven, whereas the term 'substitute' refers to a specific role (i.e., a player eligible to play a part in a specific match). References cited in the retrieved articles, and articles identified through other sources (e.g., articles known to the authorship team) were also considered for inclusion.

Based upon the initial screening of titles and abstracts, nineteen full-text articles were assessed with reference to the pre-defined exclusion criteria. During this process, six were removed; a single record being a review article, another did not pertain to soccer directly, and four articles considered only 'non-starters'. Therefore, thirteen records were retained and included in the review**.** Records were pooled into three main themes, with six studies reporting the patterns of introduction of substitutes (Table I), seven investigating substitutes' match-performances (Table II), and three articles addressing the psychology of substitute players (Table III). Articles investigating multiple concepts are included in more than one theme.

****INSERT TABLE I HERE****

****INSERT TABLE II HERE****

****INSERT TABLE III HERE****

## 3.0 FINDINGS AND DISCUSSION

### 3.1 Patterns of introduction of soccer substitutes

Pooling data from the English Premier League, Italian Serie A, and La Liga in Spain, highlighted that the mean time of introduction for first, second, and third substitutes was at 57, 71, and 81 min, respectively [33], although the mean data for the first substitution was likely skewed by the occasional need for first-half replacements (mostly related to player injury). Nevertheless, the first replacement was most often introduced at half-time, whereas the greatest frequencies of second and third substitutions were at 70 min and 90+ min (i.e., during second-half stoppage-time), respectively [33]. Interestingly, the specific leagues in question appeared to influence the timing of the first, but not second or third replacements, with English Premier League managers making their first substitution later (i.e., 58$^{th}$ min) than those in Italy (i.e., 52$^{nd}$ min). Whilst these discrepancies were attributed to differences in managerial styles [33], the physical demands may also vary between leagues and thus influence substitute timings. Indeed, although most positions' activity profiles appear similar across competitions, and whilst acknowledging the continual evolution of the game [32, 34], attackers in the English Premier League may perform less HIR than those in the Spanish or Italian top divisions [35]. Therefore, speculatively, a lower volume of HIR for English Premier League attackers may delay the accumulation of fatigue and thus temporarily defer the need to replace them when compared with their European counterparts.

Bradley et al. [22] observed that the majority of English Premier League replacements were made at half-time or between 60-85 min, with substitutions becoming more 'offensive' (i.e., attackers and midfielders) as the second-half progressed. This finding conflicts with a study in the Spanish first division in which the number of replacements increased from 46-70 min, with a greater probability of a substitution being 'defensive' as the match went on [36]. It should be considered that even an 'offensive' substitution (from a player position perspective) can be made with defensive intent (e.g., to use up time), but further inter-competition differences in the types and timing of substitutions are noted [22, 33, 36].

In line with observations from European top-tier competitions, French League 1 substitutes were reported to typically spend 23±8 min and 25±7 min on the pitch, respectively, suggesting that they were introduced midway through the second-half [37]. Interestingly, even when unlimited 'rolling' substitutions were permitted during NCAA women's competition, forwards were the only position for whom players being substituted into the match had significantly lower second-half playing time (i.e., 20±2 min vs 30±2 min) than those substituted out [25]. Whilst this is the only published article that reports the playing times for starting and substituted players in this population, observations of ~12 interchanges per game, with only four players routinely completing 90 min [25], suggests a vastly different scenario from FIFA competitions, which may have implications in terms of players differential physical responses between competitions.

Teams that are behind in a match tend to make their initial substitution sooner than when ahead [33, 36], a trend which may exist for all three replacements in FIFA-regulated 90 min matches [33]. It therefore appears that managers whose team is behind have a greater inclination to alter tactics in an attempt to change the direction of a match. Moreover, players on teams that are losing at the time of a substitution are more likely to be deemed 'underperforming' than those who have been able to produce a lead for their team [33]. Accordingly, score-line is an important factor influencing the introduction of substitutes.

The effect of location on the timing of substitutions is unclear. For example, relative to away games, a higher probability of making a first replacement at half-time may exist when playing at home [36], yet observations across three European leagues reported no effect of match location except for the third substitution being made *later* when playing at home [33]. Potentially, as home managers are more likely to face crowd pressure, they may seek to avoid negative scrutiny by making changes at half-time [36], and because home advantage means teams are less likely to be behind in the match, the likelihood of the final substitute being delayed is increased [33]. Further research is required to enable firm conclusions to be drawn, and should consider potential interactions between contextual variables.

Drawing statistics from three major European leagues, Myers [33] used decision trees to propose a 'rule' for optimising the timing of substitutions. The analysis revealed that when a team was behind in a match, the probability of improving their score differential was increased if their first substitution was made before the 58$^{th}$ min, the second before 73 min, and the final substitution before 79 min. Although the proposed rule was only followed in 34% of scenarios for potential application, losing teams improved their goal differential in 38-47% of cases when the rule was followed, compared with 17-24% of matches otherwise [33]. However, Silva and Swartz [38] criticised this approach as too simplistic, and considered a Bayesian logistic regression based upon a prior distribution in which team strength was related to the probability of the trailing team scoring the next goal. Using the same data as Myers [33], they found no discernible time-period in which there was a clear benefit to making a substitution. It is clear that the majority of teams across the top professional competitions (~82%) make all three substitutions permitted [33]. However, although observations suggest that substitutes typically receive match-specific tactical information from coaches immediately prior to pitch-entry, no study has examined the exact reason for managers making particular substitutions. This would be a beneficial area for future investigation, perhaps using qualitative methods, to provide valuable insight into the specific performance responses of the players introduced.

### 3.2 Match performance of soccer substitutes

Seven studies (Table II) have investigated the match-performances of soccer substitutes after their introduction onto the pitch, with a number of between- and within-player comparisons made over various timeframes [4, 22, 25, 37, 39, 40]. Whilst running performance may not necessarily reflect a player's overall contribution [5], total distance (TD) and HIR are the variables most commonly investigated, and HIR nonetheless represents a valid indicator of physical performance during soccer match-play [4]. To allow comparison between groups, studies typically correct match performance variables to represent indices relative to playing-time (i.e., variable·$min^{-1}$). Unlike those in many other team sports, soccer players do not typically specialise according to playing duration (i.e., whole- or partial-match players). Accordingly, it has been suggested that the length of time on the pitch is a major factor influencing match intensity [41]. Under this theory, subject to optimal pre-entry preparation, players introduced for shorter durations should be able to sustain higher-intensities than players starting a match [41]. However, existing literature has reported inconsistent findings, perhaps partly due to methodological differences, and soccer's inherent between-match variability in demands [42, 43]. Notably, Bradley et al. [22] highlight that players being introduced onto the pitch must be immediately able to perform at equivalent or higher work-rates than those being replaced, and/or other players remaining on the pitch, for a substitution to be deemed effective from a work-rate perspective. The focus on making an *immediate* impact emphasises the importance of substitutes' preparation strategies directly prior to pitch-entry. If preparation is sub-optimal, players may require the initial period of match involvement to warm-up, rather than being able to perform at the intensities expected of them. In support, preliminary investigations have indicated an inability for players introduced as substitutes to exceed the running performance that they typically adopt during the first-half of matches that they start [22, 37].

*3.2.1 Substitute performance relative to whole-match players remaining on the pitch*

Seminal work employing time-motion analysis identified that elite substitutes who had been introduced during the second-half covered 25% more HIR and 63% greater sprinting distances during the final 15 min of a game, relative to whole-match players over the same period [4]. Subsequent research has reported similar patterns [22, 37, 39], including for female players utilising unlimited interchanges [25]. In addition, a study of French League 1 midfielders identified reductions in recovery times between HIR efforts for second-half substitutes compared with other players remaining on the pitch [37]. Similarly, although limitations exist with using heart rate as a proxy for exercise intensity [1], mean second-half heart rate was significantly higher (84±3 vs 81±4% maximum heart rate) when half-time substitutes were included in the analysis, when compared with only players completing 90 min [40].

Given the wealth of literature documenting differential match demands across playing positions [4, 5, 35, 44-46], it is unfortunate that sample size considerations have limited many studies' abilities to analyse the effect of playing position for substitutes. However, a well-powered investigation by Bradley et al. [22] highlighted that whilst substitutes performed ~27% more HIR (12.4±5.3 $m \cdot min^{-1}$) than whole-match players (9.8±3.2 $m \cdot min^{-1}$), this was modulated by playing position and was not the case for fullbacks. Conversely for sprint distance, substitute fullbacks and central midfielders covered more ground than their whole-match counterparts. Substitute midfielders therefore covered greater sprint and HIR distances than whole-match players [22], and Carling et al. [37] considered only midfielders for their corresponding comparison. These findings are potentially of relevance, as professional midfielders cover greater running distances relative to any position [4, 5, 44, 45], and consequently suffer the largest between-half decrements in HIR [5, 39]. Interestingly, whilst no study has considered the match-effectiveness of substitutes' increased work-rate, central midfielders were the only position in which substitutes performed more HIR *in possession of the ball* (4.7±3.1 vs 3.8±1.9 $m \cdot min^{-1}$) than whole-match players [22].

Taken together, these findings appear to suggest a potential role for the introduction of substitutes to increase overall match-intensity relative to those around them. However, caution must be exercised when drawing conclusions based purely upon movement data as even if replacements are able to cover more ground than players remaining on the pitch, their effectiveness may rely upon the ability of other players to respond. Indeed, the primary reasons for making substitutions are tactical [21, 22], and although pass-completion rates, a key indicator of soccer success [5, 10, 26, 47], were similar between players entering the pitch and whole-match players [22], further work is necessary to determine the overall impact of substitutes when introduced. It should also be noted that strength and conditioning coaches often use movement data to inform the volume and intensity of 'top-up' conditioning sessions for players (i.e., substitutes and those being replaced) who play <90 min (empirical observations). Therefore, comparisons of match activity between substitutes and whole-match players may be important when informing the degree of 'topping-up' required.

*3.2.2 Substitute performance relative to their own habitual performance when completing a full match*

Three identified studies, each using elite European teams assessed the match-performances of players when they were introduced as a substitute compared with when they played 90 min [22, 37, 39]. Greater TD and 21% more HIR (i.e., $\geq$19.8 km·h$^{-1}$) was covered by English Premier League players as substitutes, compared with the equivalent period of the second-half, but not the first-half, of matches that they started [22]. These data support previous observations whereby substitutes covered greater TD and 15% more HIR (i.e., $\geq$14.4 km·h$^{-1}$) than the equivalent period when completing 90 min [39]. Interestingly, unlike the comparison with whole-match players above, neither study observed differences in sprinting. To determine the effect of substitution timing, players have been further categorised as either early (i.e., 45-65 min) or late (i.e., 65-90 min) substitutions, but relative between-group increases in TD and HIR when compared with whole–match players (7-8% and 14-16%, respectively) were similar [39].

With regards to the influence of playing position, findings have been inconsistent. Bradley et al. [22] reported that whilst TD was greater for substitute central defenders, attackers, and central and wide midfielders, only attackers covered more HIR as substitutes than during the equivalent second-half period when completing a whole match (11.6±3.6 vs 9.3±2.9 m·min$^{-1}$, respectively). In contrast, an earlier study observed that central midfielders were the only position for whom HIR was significantly greater as a substitute compared with the exact time period when playing a full match, whilst substitute central defenders and fullbacks completed more sprinting [39]. Therefore, position-specific factors seem to modulate the substitute response.

Carling et al. [37] compared players' activity over their initial 10 min following introduction as substitutes to their habitual performance during the opening 10 min when starting matches. The opening phase of match-play typically encompasses the most intense period of matches [48] and although no differences were observed for midfielders, forwards covered significantly *less* TD during their first 10 min of competition when introduced as a substitute. Unfortunately, no information is provided to indicate the adequacy of substitute forwards' pre-entry preparation (e.g., rewarm-ups), but the authors suggest that the discrepancy between positions may also be related to their respective tactical roles, and difficulties for substitute forwards to 'get into the game' [37]. Such inter-position variation highlights the importance of coaches making substitutions based upon situational and positional considerations, such as the tactical role, amount of HIR performed, and level of conditioning of players in any given position [22, 39].

### *3.2.3 Substitute performance relative to the players being replaced*

Given that an attempt to offset the effects of fatigue is a major motivation for managers in making substitutions [22], an important consideration may be the ability of substitutes to increase running intensity compared with the player that they directly replace – assuming a tactical change does not occur simultaneously. However, such analyses have rarely been conducted, and findings are difficult to reconcile. A preliminary investigation using French Division 1 players observed no significant differences in running performance between substitute forwards and the second-half period of those players being replaced, although in midfielders, substitutes covered greater TD ($136.6\pm9.1$ vs $129.3\pm3.6$ $m\cdot min^{-1}$) [37]. However, due to its involvement in many of the most decisive passages of play [31], HIR rather than TD is considered the primary indicator of physical performance in soccer [4].

When performances of English Premier League starters and their direct replacements were compared, substitutes covered greater TD and 10% more HIR, with fullbacks being the only position for whom substitutes' HIR did not exceed that of players being replaced [22]. However, despite increases in HIR, no differences were observed in pass-completion rates, and players exiting the field attained faster maximal running speeds. The latter finding may be due to increased playing duration providing greater opportunities to sprint, but may also reflect an individuals' physiological characteristics. Indeed, individuals categorised as 'starters' have demonstrated higher measures of linear speed, lower-body strength, and power than 'non-starters' across soccer [24, 49, 50], rugby league [51, 52], and Australian Football [53]. The authors acknowledged the limitations of this independent-measures analysis [22], as despite correcting for time on field (i.e., m·min$^{-1}$), discrepancies in the length of the playing time-period between starters and substitutes (e.g., 75 vs 15 min) may have influenced how indices of running performance were represented, due to differences in overall tempo or pacing strategies over different portions of a match [22, 39, 54].

In NCAA women's competitions (which permit players exiting the field to return during the second-half), few differences in physical performance have been observed between those substituted into and out of the game [25]. In the single study to have made such comparisons, the only significant differences came during the first-half, with reduced moderate-intensity running for midfielders, and a tendency towards increased HIR for defenders introduced before half-time compared with players making way [25]. Coaches in NCAA competitions use frequent interchanges (i.e., ~12 per match) in an attempt to minimise acute (within-match) and/or residual (between-match) fatigue [25]. Speculatively, the similarities in performance between players introduced and those replaced may be attributable to the shorter times on the pitch for players being removed (~31 min) compared with their counterparts in FIFA-governed competitions. It is plausible that neither playing-times for substitutes or for players being replaced are sufficient for substantial development of fatigue, with the similar work-rate profiles between players' first and final bouts of activity [25] lending credence to this suggestion.

Research has therefore provided inconclusive evidence, but highlights the potential benefits of introducing substitute players, particularly midfielders, during the second-half of FIFA-governed matches [22, 37]. However, indices of physical activity alone may not represent overall playing performance. The objective of soccer is to outscore the opposition, and a replacement may still be considered a successful substitution if they make a substantial tactical contribution, irrespective of the fact that they may display 'worse' match running performance than their exchanged counterpart [22, 37]. Indeed, an increased number of goals from substitutes was a factor discriminating a championship-winning season from less successful years in the French League 1 [55]. The importance of technical skills to the outcome of soccer matches is highlighted by observations that 16-30 attacking plays and ~10 shots are required per goal scored [10, 56], and that successful teams score a greater proportion of goals following longer passing sequences than shorter [47]. Indeed, it has been suggested that technical performance may be more important than physical activity to team success [5], and has been considered the discriminating factor between winning and losing sides in Spanish professional soccer [26].

Tactical considerations may be the primary factor motivating a manager's decision to make substitutions during soccer matches [21], and replacements may facilitate alterations in formation or strategy. Unfortunately, no study has investigated the effect of substitutions on inter-personal coordination and movement synchronisation, which may indicate a team's tactical performance [57]. The fact that pass-completion rates remained similar for substitutes compared to either the player being replaced or those remaining on the pitch for the full 90 min [22] is a potentially important observation. Whilst starting players may set a lower benchmark for comparison due to the deleterious effects of soccer-specific exercise on their ability to execute game-specific skills [7, 8, 11, 12, 15], these reports suggest that despite regulations preventing performance of ball-skills during their pre-introduction rewarm-ups, substitutes are able to meet the technical demands of the matches that they enter. However, pass-completion is not the only skill important to soccer match-play, and the influence of soccer-specific exercise appears inconsistent, and may depend upon the particular skill being performed [9, 11, 58]. Indeed, in English Championship players, no between-half decrements were observed in the number of touches taken per possession, number of challenges, percentage of challenges won, length of forward distributions, or percentage success of distributions [58]. Similarly, in the Italian Serie A, only three of the twelve indices of technical performance were significantly lower during the second-half than the first [10], and Harper et al. [15] reported that extra-time influenced only four of the seventeen variables analysed during professional European matches. Accordingly, further information regarding the technical performance of substitutes when entering the field of play is necessary.

*3.2.4 Within-match transient changes in substitute performance*

The only study to investigate substitutes' running performance over the course of a match found no significant differences between successive five min epochs following their introduction, although there was a tendency for both TD and HIR to increase as the match progressed [22]. Small-sided games have demonstrated that knowledge of task-duration influences how athletes regulate their physical output [59], but this observation appears to conflict with the suggestion that soccer substitutes respond to a shortened overall playing period by adopting unsustainably high running intensities upon entering the pitch [41]. Indeed, the performance profile observed in soccer [22] appears more akin to that reported during players' second bouts as a substitute in rugby league, whereby certainty over the task end-point (i.e., full-time) means a lower-intensity is initially adopted, to allow for a possible 'end-spurt' of heightened activity [41, 60]. The effect of matches requiring extra-time remains unclear, but during small-sided games, players have produced higher overall physical outputs when the task-duration has been unexpectedly extended, than when the full-duration was known from the outset [59]. It is therefore possible that the tendency for work-rate to increase over successive five min periods following substitutes' introduction reflects a conscious or subconscious pacing strategy, and observations that a greater proportion of goals are scored during the final 15 min of soccer matches [20] suggest transient changes in game demands. Nevertheless, this is only a single study in which no positional analysis was conducted, and the tactical nature of certain positions may hinder their opportunity to cover ground [37]. Moreover, given the logistical constraints associated with the role (i.e., restrictions on warm-ups etc.), and players' own concerns over inadequate preparation [61, 62], it must be considered whether soccer substitutes are physically and mentally 'primed' to perform *immediately* upon pitch-entry.

Half-time research has shown that ~15 min of inactivity following exercise can induce physiological processes that may limit subsequent physical performance [63-65]. Whilst other mechanisms contribute to the ergogenic effect of an active warm-up (i.e., elevated oxygen consumption, post-activation potentiation, mental state) [66-72], decreases in body temperature are proposed to play an important role in the observed declines in physical performance during the initial stages of the second half [19, 64]. Muscle temperature ($T_m$) may decrease by up to 2°C during ~15 min of inactivity and a positive correlation (r = 0.60) has been observed between the magnitude of $T_m$ decline and the reduction in sprint performance over the course of half-time [63]. Similar correlations have been observed in rugby league and rugby union between decreases in core temperature ($T_{core}$) and decrements in peak power output [73, 74]. Given that substitutes typically face lengthy delays (punctuated by only brief periods of low-intensity activity) between cessation of the pre-match warm-up and entry onto the pitch [22], it is possible that a gradual elevation of $T_m$ and $T_{core}$ could explain the potential improvements in physical performance seen as playing duration increases. Indeed, in professional rugby union players, the performance benefits of passive heat-maintenance (i.e., survival jacket) employed during a simulated half-time were nullified versus the control trial after the first two sprints of the second-half, a response attributed to exercise itself raising body temperature in the no heat-maintenance condition [74]. To support or refute the suggestion that substitutes' pre-entry activities inadequately prepare players to immediately perform to their capacity, further work should investigate the physiological and performance responses to current practices. Additional research into transient changes in substitutes' activity profiles over the duration of their on-field bout would also be beneficial.

### 3.3 Experiences of soccer substitutes

Three studies have considered the position of soccer substitutes from a psychological standpoint (Table III), either as a primary aim [62], or as part of wider research documenting players' mental states [61, 75]. Woods and Thatcher [62] individually interviewed fifteen semi-professional and five professional soccer players, both male and female, to explore their emotional responses to being selected as substitutes. During both the 'pre-game' and 'performance' periods, substitutes reported mainly negative experiences, broadly categorised into 'person' and 'organisational' factors. Person factors included dissatisfaction with status, self-presentation worries, lack of control over their own performance and coaches' decisions, reduced motivation to prepare, and increased anxiety. Organisational factors centred on restriction of substitutes' ability to prepare, lack of communication/explanation from coaches, and segregation from other team members. Being named 'on the bench' has previously been identified as a source of stress for players, who take dissatisfaction at the lack of control, and may view the position as one of diminished status [61, 76]. Indeed, even when players experience success as a substitute, this may foster fears of becoming typecast in this 'lesser' role [62]. Conversely, it is plausible that a more positive view of the position may be taken within squads adopting a known 'rotation policy', by those players for whom being named as a substitute provides opportunities to return to play following injury/absence, or for youth players to achieve 'game-time'.

Self-presentation concerns, and anxiety surrounding their perception by others [61, 62], may see substitutes align themselves with social goals (i.e., to prove their worth) that detract from their match-focus [62]. Because mental-state has the potential to influence hormonal and performance responses [77, 78], coaches and psychologists must maintain an awareness of substitutes' possible negative emotions, and devise methods by which players are able to cope with their role and pursue task-orientated goals [61, 62, 75, 79]. Notably, the ability to complete a routine warm-up has been identified as an effective coping mechanism to help maintain task-focus in international women's players [61].

It is clear that the substitute populations considered to date have associated the position with overwhelmingly negative experiences. However, although no respondents were happy with their status as substitutes, more positive sentiments were expressed by those individuals who managed to accept the role, and retain confidence in their ability to perform [61, 62]. Whilst a strikingly negative reaction from a professional player is recalled by Gilbourne and Richardson [75], it remains to be seen whether the emotional responses of substitutes at the highest level of soccer, who are often well remunerated, or in leagues with different substitution rules (e.g., NCAA competitions), mirror those reported by Woods and Thatcher [62]. An interesting avenue for future research would be to consider the emotional state of substitutes with reference to particular contextual variables. For example, it would appear logical to posit that experiences may contrast between substitutes who are introduced during a match, and those who remain unutilised. Investigations to date appear to assume that all players expect to be selected in the starting eleven, whereas a more positive outlook may be had by a player named as a substitute after an injury layoff, a designated 'impact substitute', or a youth player making their first-team debut. Moreover, the influence of selection frequency on players' attitudes has not yet been examined.

## 4.0 CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The strategic introduction of substitutes is common practice during soccer matches, whereby managers seek to alter tactics, replace underperforming players, mitigate the effects of fatigue across a team [22], and/or to provide certain players with playing-time. Given the between-match variation [42, 43], and influence of situational variables on the pattern of soccer match-play (e.g., game location, pitch dimensions, score-line, quality of opposition, stage of season[39, 80-82]), it is unsurprising that research to date has produced inconsistent and sometimes conflicting results. Nevertheless, a consensus exists that teams generally use their full allocation of substitutes, and that tactical (i.e., not injury-related) replacements are predominantly made at half-time or during the second-half, with league [33], score-line [33, 36], and potentially match location [36] independently influencing the timing of one or all three replacements. It is also clear that players selected as substitutes experience overwhelmingly negative emotions, and the development of appropriate coping strategies should be encouraged to allow substitutes to maintain task-focus [61, 62, 75].

Less apparent is the impact that substitutes have when introduced into a match. Evidence suggests that replacement players, particularly midfielders, cover greater distances than those achieved over the equivalent time period by players who started the match [4, 22, 37, 40]. However, when compared with the performances of the players being replaced, findings are less conclusive. Whilst substitutes cover greater TD [22, 37], reports in relation to HIR are conflicted [22, 37], with such observations perhaps being attributable to the inherent degree of between-match variation in high-speed activities [39, 42]. It also appears that players are able to perform more HIR when introduced as substitutes than during the equivalent period when they complete 90 min, although they fail to exceed the intensity adopted during the first-half of matches that they start [22, 37, 39].

Despite these observations with regards to work-rate, the only indicator of technical performance examined to date has showed no differences in pass-completion rates [22].

Sample sizes have largely limited the ability to make comparisons across positions which, given differences in physical demands [4, 5, 35, 44-46], and the frequency with which positions are substituted [22, 36], may be an important consideration. The evidence that does exist suggests that substituting midfielders may provide the greatest increase in work-rate [22, 37], and this is indeed the most frequent replacement [36]. Unfortunately, no study has combined analyses of on-field performance with the reasons for players' introduction, or considered the impact of substitutions on the work-rate of players remaining on the pitch. This may be particularly pertinent given that numerous competitions are currently piloting rules permitting additional substitutions in matches that require extra-time, changes which practitioners appear in favour of [83]. Such investigations could facilitate an evaluation of the efficacy of a change, with particular reference to the specific variables being targeted. Moreover, the inclusion of a wider range of technical performance indicators may shed further light on the match-impact of substitute players, especially given the inconsistent effects of soccer-specific exercise across different skills [10, 15, 58].

Whilst only a single study has investigated transient changes in physical performance following a player's introduction as a substitute, a trend towards increasing TD and HIR over successive 5 min periods was observed [22]. This raises further questions over substitutes' readiness to perform immediately upon pitch-entry, and it is important to evaluate the current pre-entry strategies of substitute players whilst they await introduction. On a related note, we are unaware of any research that has investigated substitutes' acute physiological responses to match-play. As well as determining whether body temperature is maintained until the time of introduction, analysis of glycogen depletion, energy expenditure and substrate utilisation, as well as blood markers such as glucose concentrations, lactate accumulation, and acid-base balance, would contribute to the knowledge currently available pertaining to substitutes and may aid in devising appropriate preparatory strategies. Such investigations could be combined with analysis of substitutes' dietary practices, which may logically differ from those of players completing 90 min.

No study has yet measured the magnitude of the post-exercise fatigue response when players have been introduced as substitutes. It is well documented that 90 min of soccer-specific exercise produces significant reductions in muscle contractile properties, jump and sprint performance, and elevations in markers of muscle damage and inflammation, with many of these measures remaining impaired beyond 72 hours post-match [84].

As fatigue-management may be a substantial motivating factor for the use of substitutes [25], an investigation into the acute (i.e., post-match) and residual (i.e., +24-72 hours) effects of soccer match-play within partial-match players would be of use for practitioners seeking to devise appropriate 'top-up' conditioning sessions, tailor implementation of recovery practices, or to manage fatigue across a squad.

This review has explored the literature currently existing in relation to soccer substitutes. The authors acknowledge that methodological differences, and the inherently reactive or unpredictable nature of substitution practices, make firm conclusions difficult to draw. Nonetheless, this article has taken a broad approach, and has attempted to reconcile the few investigations that have been conducted into substitute players. Advocating an 'assess then address' approach, we have highlighted a number of avenues for future research which may not only enhance awareness surrounding current practices, but impact positively on substitute players when introduced into soccer matches.

## COMPLIANCE WITH ETHICAL STANDARDS


### Funding

No sources of funding were used to assist in the preparation of this article.


### Conflicts of Interest

Samuel Hills, Martin Barwood, Jon Radcliffe, Carlton Cooke, Liam Kilduff, Christian Cook and Mark Russell declare that they have no conflicts of interest relevant to the content of this review.

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**LEGENDS**

**Fig 1:** Exemplar model derived from empirical observations of current substitute practises on match-day with player introduced after 75 min (i.e. ~90 min post kick-off). Observations are based upon one team, and other clubs may vary in their routines.

**Table I:** Studies examining the patterns of substitutes' introduction

**Table II:** Studies examining the soccer match-performance of substitutes

**Table III:** Studies examining the emotions or experiences of soccer substitutes

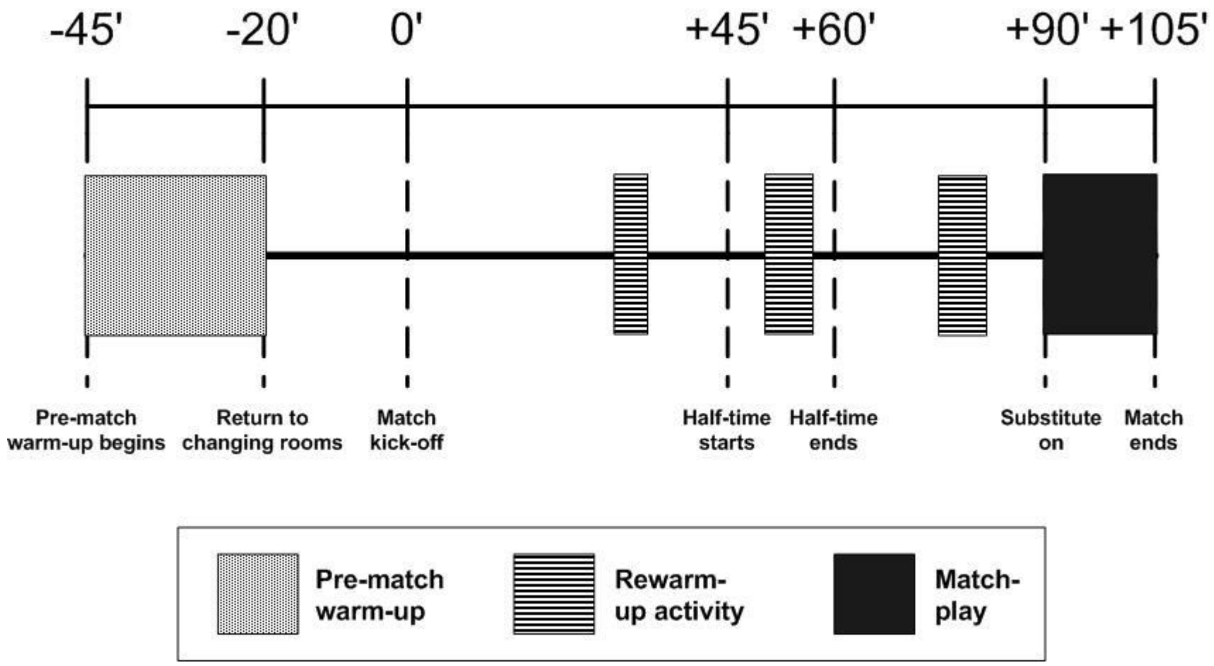


**Fig 1:** Exemplar model derived from empirical observations of current substitute practises on match-day with player introduced after 75 min (i.e. ~90 min post kick-off). Observations are based upon one team, and other clubs may vary in their routines.

**Table I:** Studies examining the patterns of substitutes' introduction

| Study | Players | Data collection | Variables measured | Key results |
|---|---|---|---|---|
| Del Corral et al. 2007 [36] | Spanish Division 1 players. 2108 subs made in 380 matches (including 676 1st subs). | Referees' official post-match reports. | Time of substitution, position of replacement, and factors influencing timing. | Number of subs ↑ from 46-70 min, then ↓ from 70-90 min.<br>MF-MF subs most common (825 observations).<br>Offensive subs more common, defensive sub ↑over time.<br>Score (losing teams: 1st sub earlier) and match location (home teams: 1st sub earlier) influence timing. |
| Carling et al. 2010 [37] | French Division 1 MF and CF (n=25 subs), observed over 18 matches. | Multiple-camera tracking system. | Time on field. | MF subs played 22.5±8.1 min and CF subs played 24.8±7.4 min (only subs playing >10 min included). |
| Myers 2012 [33] | 485 observations from English Premier League (155), Italian Serie A (172), and La Liga in Spain (158). | Data provided by ESPN Soccernet. | Time of substitution, factors influencing timing, score differential. | Mean subs introduction times were 57 (1st subs), 71 (2nd subs), and 81 (3rd subs) min.<br>Score line (losing teams: 1st subs earlier), and league (Serie A 1st subs: 52 min, Premier league 1st subs: 58 min) influence timing.<br>Best outcomes: when team is behind, make 1st subs <58th min, 2nd subs <73rd min, 3rd subs <79th min. |
| Bradley et al. 2014 [22] | English Premier League players (n=286 subs). | Multiple-camera tracking system. | Time of substitution and position of replacement. | Most subs made at half time or 60-85 min.<br>More offensive (attackers and WM and CM) vs defensive (CD and FB) subs between 60-90 min. |
| Vescovi and Favero 2014 [25] | NCAA Division 1 women's players (n=113), 1 observation per player[a]. | Wearable GPS; 5 Hz. | Time on field. | 1st half: replaced players had ↑ time on field vs subs: F (30.0±1.5 vs. 19.0±2.0 min), MF (31.0±1.5 vs. 18.0±1.8 min), DF (32.0±1.2 vs. 12.0±1.9 min).<br>2nd half: replaced F had ↑ time on field vs subs (30.0±2.0 vs 20.0±1.5 min), but ↔ for MF (25.0±3.2 vs 22.0±2.1 min) and DF (21.0±4.4 vs 29.0±3.1 min). |
| Silva and Swartz 2016 [38] | Same data as Myers (2012), plus additional 3 seasons from English Premier League, 4226 observations. | Data provided by ESPN Soccernet. | Time of substitution, and score differential. | No discernible time period where there is a clear benefit to making a substitution. |

GPS: Global positioning system, Hz: Hertz, NCAA: National Collegiate Athletic Association (USA), Subs: Substitutes, ↑: Higher than/increased, ↓: Lower than/decreased, ↔: No difference. [a]unlimited interchanges. MF: Midfield player, F: Forward player, CF: Centre-forward player, CD: Central defender, FB: Fullback, DF: Defender, WM: Wide midfield player, CM: Central midfield player.

**Table II:** Studies examining the soccer match-performance of substitutes

| Study | Players | Data-collection | Variables measured | Key results |
|---|---|---|---|---|
| Mohr et al. 2003 [4] | Elite European team (n=13 2nd half subs), 1-4 observations per player. | Video time-motion analysis. | Distances (m) covered across various speed thresholds. | Subs covered 25% ↑ HIR (>15 km·h$^{-1}$; 0.40±0.03 vs. 0.32±0.03 km), and 63% ↑ sprinting (>30 km·h$^{-1}$; 0.13±0.01 vs. 0.07±0.00 km) distances at 75-90 min vs. whole-match players. |
| Carling et al. 2010 [37] | French Division 1 MF and CF (subs: n=25), observed over 18 matches. | Multiple-camera tracking system. | Distances (m) covered (·min$^{-1}$) over various speed thresholds, and recovery time between high-intensity actions. | MF subs covered ↑ 2nd half TD (136.6±9.1 vs 129.3±3.6 m·min$^{-1}$) vs. players replaced.<br>MF subs covered ↑ TD (136.6±9.1 m·min$^{-1}$), HIR (19.1-23 km·h$^{-1}$; 9.8±3.6 m·min$^{-1}$), and ↓ recovery-times between HIR efforts (95.1±38.5 s) vs. whole-match MF.<br>F covered ↓ TD during initial 10 min as a sub vs. their initial 10 min when starting. |
| Coelho et al. 2012 [40] | Brazilian Division 1 (subs: n=15) players, observed over 29 matches. | HR monitor. | % $HR_{max}$ and time in various HR zones. | ↑ 2nd half HR (84±3 vs 81±4% $HR_{max}$) when subs included vs whole-match players alone, HR remained ↓ vs. 1st half HR for full-match players (86±3% $HR_{max}$). |
| Bradley and Noakes 2013 [39] | English Premier League players (n=65), observed completing full matches and when introduced as subs. | Multiple-camera tracking system. | Distances (m) covered (·min$^{-1}$) over various speed thresholds. | Subs covered ↑ TD (117.2±1.7 vs. 109.2±1.7 m·min$^{-1}$) and HIR (≥14.4 km·h$^{-1}$; 32.5±1.2 vs. 28.3 ± 1.0 m·min$^{-1}$, +15%) vs. equivalent period when playing a full match.<br>CD and FB ↑ sprinting (>25.1 km·h$^{-1}$) as subs vs. equivalent time playing full match (1.85±0.39 vs. 1.11±0.34 and 3.85±0.59 vs. 2.86±0.49 m·min$^{-1}$, respectively).<br>Subs covered ↑ TD and HIR than the mean of all on-field players. |
| Bradley et al. 2014 [22] | English Premier League players, whole-match (n=810), subs (n=286), players replaced (n=286). | Multiple-camera tracking system. | Distances (m) covered (·min$^{-1}$) over various speed thresholds, and pass completion rates. | Subs covered ↑ TD (120.1±14.5 m·min$^{-1}$) and HIR (≥ 19.8 km·h$^{-1}$; 12.4±5.3 m·min$^{-1}$) vs. whole-match (TD: 112.3±10.3, HIR: 9.8±3.2 m·min$^{-1}$), and replaced players (TD: 116.2±10.6, HIR: 11.3±3.2 m·min$^{-1}$).<br>Subs covered ↑ TD (118.1±13.6 vs. 105.9±16.2 m·min$^{-1}$), and HIR (12.2±4.7 vs. 10.1±4.1 m·min$^{-1}$) as subs vs. their habitual 2nd half performances when playing full match.<br>↔ for pass-completion rates.<br>Trend for ↑ TD and HIR over successive 5 min blocks for subs. |
| Vescovi and Favero 2014 [25] | NCAA Division 1 women's players (n=113), 1 observation per player[a]. | Wearable GPS; 5 Hz. | Distances (m) covered (absolute and ·min$^{-1}$) across various speed thresholds. | ↑ HIR (15.6–20.0 km·h$^{-1}$) between 78-90 min for players re-introduced vs. whole-match players (9.0 ± 0.6 vs. 6.0 ± 0.4 m·min$^{-1}$).<br>1st half: MF subs covered ↓ moderate-intensity (12.1–15.5 km·h$^{-1}$) distance·min$^{-1}$ vs. those replaced (15.0±1.8 vs. 19.0±0.9 m·min$^{-1}$).<br>DF playing whole 1st half covered ↓ HIR (6±1 m·min$^{-1}$) vs. players introduced (16.0±2.8 m·min$^{-1}$) or replaced (11.0±1.0 m·min$^{-1}$). DF subs covered ↑ 1st half HIR vs. those replaced. |
| Carling et al. 2015 [55] | French league 1 team over 5 seasons (190 matches). | Multiple-camera tracking system. | TD, HSR distance (≥19.1 km·h$^{-1}$), and technical KPIs. | ↑ matches won by goals from subs (+5), matches won between 75-90 min (+7) during successful vs other seasons.<br>↑ goals scored, ↓ goals conceded during 2nd half injury time. |

GPS: Global positioning system, HIR: High-intensity running distance, HR: Heart rate, $HR_{max}$: Maximum heart rate, HSR: High-speed running, Hz: Hertz, KPI: Key performance indicator, NCAA: National Collegiate Athletic Association (USA), Subs: Substitutes, TD: Total distance, ↑: Higher than/increased, ↓: Lower than/decreased, ↔: No difference. CD: Central defender, FB: Fullback, MF: Midfield player, F: Forward player, CF: Centre-forward player, DF: Defender. [a]unlimited interchanges

**Table III:** Studies examining the emotions or experiences of soccer substitutes

| Study | Players | Data collection | Negative experiences | Positive experiences | Coping strategies |
|---|---|---|---|---|---|
| Holt and Hogg 2002 [61] | International women's players (n=7). | Face-to-face interviews. | Stress, pressure, fear, anxiety, lack of preparation, self-presentation concerns, lack of confidence, lack of certainty/communication of role. | Having a good start. | Task-focus (e.g. routine warm-up). Supportive behaviour from teammates, parents, and significant others. |
| Gilbourne and Richardson 2006 [75] | Professional player (n=1). | Psychologist's observations and reflections. | Anger, upset, frustration, lack of belonging, rejection, loneliness, embarrassment. | Psychologist can help with role acceptance. | Caring environment is essential (psychologist can aid this). |
| Woods and Thatcher 2009 [62] | Semi-professional (n=15; 12 male, 3 female), and professional (n=5) players. | Face-to-face training ground interviews. | Person factors: dissatisfaction, self-presentation concerns, reduced control, reduced motivation, anxiety, pressure.<br><br>Organisational factors: short notice, segregation, poor communication/explanation, restricted preparation. | Some role acceptance, task-focus, and confidence. | Coaches should provide communication and be aware of how to help subs cope with the role. |

Subs: substitute