Profiling the Post-match Top-up Conditioning Practices of Professional Soccer Substitutes: An Analysis of Contextual Influences

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Abstract

Hills, SP, Barrett, S, Busby, M, Kilduff, LP, Barwood, MJ, Radcliffe, JN, Cooke, CB, and Russell, M. Profiling the post-match top-up conditioning practices of professional soccer substitutes: An analysis of contextual influences. J Strength Cond Res 34(10): 2805–2814, 2020—Soccer practitioners implement “top-up” conditioning sessions to compensate for substitutes’ limited match-play exposure. Although perceived to be valuable for reducing injury risk and augmenting positive physical adaptations, little research has considered the demands of post-match top-up training. To quantify post-match top-up responses, 31 professional soccer players wore 10 Hz microelectromechanical systems after 37 matches whereby they were selected in the match-day squad as substitutes (184 observations; 6 ± 5 observations-player-1). Linear mixed models and effect sizes (ES) assessed the influence of contextual factors on 23 physical performance variables. Top-ups lasted 17.13 ± 7.44 minutes, eliciting total and high-speed distances of 1.7 ± 6.2 km and 0.4 ± 1.7 km, respectively. Each contextual factor (i.e., position, substitution timing, match location, result, time of day, stage of the season, and fixture density) influenced at least 4 of the dependent variables profiled (p ≤ 0.05). Top-up duration; total, moderate-speed, and low-speed distance; and the number of repeated high-intensity efforts were greater for unused vs. used substitutes (ES: 0.38–0.73, small to moderate). Relative to away matches, home top-ups elicited heightened total, low-speed, and high-speed distances, alongside more moderate-speed accelerations and decelerations, and repeated high-intensity efforts (ES: 0.25–0.89, small to moderate). Although absolute and relative running distances were generally the highest when the fixture density was low, the greatest acceleration and deceleration demands were observed during the most congested fixture periods. Late-season top-ups typically elicited lower absolute physical responses than early and mid-season sessions. These data provide important information for practitioners when considering the aims and design of substitute top-up conditioning sessions, particularly with reference to contextual influences.

Key Words: football, physiology, monitoring, high-speed running, training

Introduction

In professional soccer, team managers or coaching staff often use substitutions to provide a physical or tactical impact on a match, and thus potentially improve scoreline differentials (21). Strategic substitutions (i.e., replacements that are not made due to injuries sustained by on-pitch players) are most often made at halftime or during the second half of match-play (6,17,18,20), with individuals entering the pitch typically exceeding the relative total distance (TD) and high-speed running (HSR) distance of players who started a match (6,20). However, substitutes consistently experience substantially lower absolute match-play demands compared with players who complete the full 90 minutes (18), although their reduced playing time may also restrict a substitute’s opportunity to attain the “peak” HSR responses of their whole-match counterparts (19).
nonselected soccer players. If an individual’s exposure to HSR and SPR is restricted by a lack of playing time, and these deficits are not addressed through training, a lesser stimulus for the promotion of physical adaptation could be experienced that may increase injury risk due to declines in ongoing loading (4,10,11). Notably, when a combined match-play and training load was quantified across an English Premier League season, habitual “nonstarters” (defined as individuals who were selected in the starting team in <30% of matches) accumulated significantly lower HSR (19.9–25.1 km·h⁻¹; ~19 vs. ~35 km) and SPR (>25.2 km·h⁻¹; ~3 vs. ~11 km) distances compared with players who started in ≥60% of matches (2).

As the principle of reversibility suggests potential negative adaptations resulting from substantial fluctuations or ongoing reductions in physical loading (10,11,29), practitioners working in professional soccer frequently implement extra “top-up” conditioning sessions for unused and partial-match players (9,10,21). In these scenarios, assuming that a period of reduced loading is not desired as part of the periodized training program, squad members who face limited match-play demands (i.e., typically determined based on the number of minutes played or assessments of the absolute physical demands experienced) undergo additional training in an effort to compensate for their lack of playing time (21). Although their unique match demands may suggest a benefit to implementing bespoke training and nutrition strategies for substitutes and nonselected players throughout the training week, uncertainty about an individual’s future match-play exposure often requires practitioners to ensure that all players are equally prepared for the physical, tactical, and psychological demands of completing a full match (21). For example, managers may not reveal the final team selection until the day before a game, whereas players named in the match-day squad as substitutes could be required to play for anything from 0 (i.e., if not introduced during a match) to 90+ minutes (i.e., if a starting player suffers injury or illness before or shortly after the match kickoff). Therefore, acknowledging that extra conditioning sessions may occasionally be undertaken at a team’s training facility during subsequent days, a desire to ensure adequate recovery before the next fixture while avoiding prolonged periods of reduced physical loading means that top-ups are typically performed on the pitch immediately post-match (21).

Although match-day may represent an important opportunity to provide a conditioning stimulus for players who receive little or no match-play exposure, several practical and logistical considerations may modulate the activities that can be performed directly after a match ends (21). Professional soccer fixtures are often contested late at night or at venues situated long distances away from home, whereas the pitch-protection policies adopted by specific teams or governing bodies may restrict pitch usage during the immediate post-match period (21,33). Despite practitioners recognizing the potential importance of top-up sessions for helping to maintain an appropriate degree of physical loading for all players within a team (21), we are unaware of any study to have directly profiled the post-match conditioning practices of players selected in the match-day squad as substitutes. Therefore, the aim of this study was to quantify the physical responses of professional soccer substitutes during post-match top-up sessions while investigating contextual influences. Such information would represent a valuable addition to the limited literature concerning the preparatory practices of this underresearched population of soccer players and may help practitioners and regulators in optimizing current approaches for substitutes.

Methods

Experimental Approach to the Problem

To quantify the physical responses elicited during post-match top-up sessions, professional soccer players were monitored using wearable microtechnology during the ~60 minutes immediately after fixtures in which they were named in the match-day squad as substitutes. To maintain consistent treatment of all squad members on “match day plus one” and to ensure adequate recovery before upcoming fixtures, the reference team targeted the immediate post-match period as the primary opportunity to undertake top-up conditioning sessions. Top-ups were designed and overseen by physical performance coaches working with the team and aimed to ensure that players achieved individualized weekly physical loading targets by offsetting their limited match-play exposure. Post-match sessions typically consisted of ~15–30 seconds straight-line running intervals performed between the halfway line and the goal line, during which a player’s distance to be covered per interval was prescribed based on an appropriate percentage (i.e., according to the stage of the periodized program) of their maximum aerobic speed. Microelectromechanical systems (MEMS) data were collected from both “used” (i.e., players who had been introduced at some time during the match) and “unused” (i.e., players who were named in the match-day squad but did not participate in any match-play) substitutes while the influence of several situational variables was examined.

Subjects

Following approval from the School of Social and Health Sciences Research Ethics Committee at Leeds Trinity University, 31 professional players from an English Championship soccer club (age: 26 ± 5 years (range 18-35 years), stature: 1.82 ± 0.07 m, body mass: 77.0 ± 7.2 kg) volunteered to participate in this study. Of the 46 first-team fixtures profiled over 12 months, post-match top-ups were performed on 37 occasions, from which 184 individual player observations were analyzed (6 ± 5 observations-player⁻¹, range: 1–17 observations-player⁻¹). All players were briefed about the risks and benefits of participation before providing their written informed consent in advance of data collection taking place during the 2018/2019 and 2019/2020 English Championship seasons.

Procedures

Players’ movements during top-up sessions were quantified using MEMS (10 Hz; S5, OptimEye, Catapult Innovations, Melbourne, Australia), which were worn beneath the playing jersey and harnessed between the scapulae in a vest designed to minimize movement artifacts. Sampling at 10 Hz has produced acceptable reliability (coefficient of variation; CV% = 2.0–5.3%) when assessing instantaneous velocity (36), alongside small-to-moderate typical errors of the estimate (1.87–1.95%) vs. a radar gun when measuring sprinting speed (32). The 100 Hz accelerometers within the MEMS devices have also demonstrated good intraunit (CV% = 0.9–1.1%) and interunit (CV% = 1.0–1.1%) reliability within both laboratory and field test scenarios (5). All players were familiar with this form of activity monitoring as part of routine practices at the club, and each player wore the same MEMS unit on each occasion to avoid potential interunit variation.

The MEMS devices were activated according to the manufacturer’s guidelines ~30 minutes before the pre-match warm-up, and raw data files were exported after the conclusion of exercise using proprietary software (Sprint 5.1.7, Catapult Innovations).
Files were trimmed on an individual player basis to ensure that only data pertaining to post-match conditioning activities were retained for analysis. Session duration as well as a combination of Global Positioning Systems-derived and accelerometer-derived variables relating to TD, low-speed running (LSR) distance, moderate-speed running (MSR) distance, HSR, SPR, PlayerLoad (PL), maximum velocity achieved, repeated high-intensity efforts (RHIEs), accelerations, and decelerations were profiled (Table 1). These variables were chosen to reflect performance indicators reported in existing substitutes literature (17,18). In keeping with the observational nature of the study, no attempt was made to influence players’ responses as part of this research.

### Statistical Analyses

Linear mixed models were used to assess the influence of several contextual factors on the physical responses elicited during post-match top-ups. Separate models were constructed for each dependent variable, whereby “player” and “match” were modelled as random effects in all instances. Contextual factors reflecting playing position (“midfielders,” “attackers,” “defenders,” and “goalkeepers”) and substitution timing during the match immediately beforehand (“unused,” “introduced at 75:00+ minutes,” and “introduced at 60:00–74:59 minutes”; note that no post-match top-ups were performed by substitutes introduced before 60:00 minutes of match-play in any given instance), stage of the season (“early-season”: August-October, “mid-season”: November-January, and “late-season”: February-April), match result (“win,” “draw,” and “loss”), location (“home” and “away”), and time of day (“early”: kickoff at 12:00–14:59 hours; “afternoon”: kickoff at 15:00–17:59 hours, and “evening”: kickoff later than 18:00 hours) were separately specified as fixed effects. Fixture density was also entered as a fixed effect and was defined on a rolling basis as the number of additional (i.e., not including the match completed on the same day as the top-up session) fixtures scheduled for the reference team within the preceding and subsequent seven-day periods combined (“high-density”: 3 additional matches; “moderate-density”: 2 additional matches; and “low-density”: one additional match). Pairwise comparisons were made using least squares means tests to assess differences between each level of any given fixed effect, before standardized effect sizes (ES) were calculated and interpreted as follows: 0.00–0.19, trivial; 0.20–0.59, small; 0.60–1.20, moderate; 1.21–2.0, large; and >2.01, very large effects (22). Analyses were conducted using RStudio (v R-3.6.1.). Descriptive statistics are presented as mean ± SD, and ES are presented with 90% confidence intervals (CI).

### Results

Table 2 indicates the overall physical demands recorded during post-match top-ups and highlights the influence of playing

| Measurement                  | Variable                  | Definition                                      |
|------------------------------|---------------------------|-------------------------------------------------|
| Distance covered             | TD (m)                    | Total amount of distance covered by any means    |
|                              | Relative TD (m·min⁻¹)     | Total amount of distance covered per min         |
|                              | LSR (m)                   | Distance covered at a speed of ≤4 m·s⁻¹          |
|                              | Relative LSR (m·min⁻¹)    | Distance covered per min at a speed of ≤4 m·s⁻¹  |
|                              | MSR (m)                   | Distance covered at a speed of >4 to ≤5.5 m·s⁻¹  |
|                              | Relative MSR (m·min⁻¹)    | Distance covered per min at a speed of >4 to ≤5.5 m·s⁻¹ |
|                              | HSR (m)                   | Distance covered at a speed of >5.5 to ≤7 m·s⁻¹  |
|                              | Relative HSR (m·min⁻¹)    | Distance covered per min at a speed of >5.5 to ≤7 m·s⁻¹ |
|                              | SPR (m)                   | Distance covered at a speed of >7 m·s⁻¹          |
|                              | Relative SPR (m·min⁻¹)    | Distance covered per min at a speed >7 m·s⁻¹      |
| Running speed                | Peak velocity (m·s⁻¹)     | Highest running speed attained                   |
| PL                           | Relative PL (AU-min⁻¹)    | Quantification of external workload: Square root of the summed rates of change in instantaneous velocity in each of the 3 (forward, sideways, and upward) vectors, divided by a scaling factor of 100 |
| Acceleration/deceleration    | High-intensity accelerations (#) | Count of the number of accelerations >3 m·s⁻² for a period of ≥0.4 s |
|                              | Moderate-speed accelerations (#) | Count of the number of decelerations <−3 m·s⁻² for a period of ≥0.4 s |
|                              | Moderate-decelerations (#) | Count of the number of decelerations <−2 to ≥−3 m·s⁻² for a period of ≥0.4 s |
| Acceleration/deceleration    | High-speed acceleration (m) | Distance covered while accelerating at >3 m·s⁻² |
|                              | High-speed deceleration (m) | Distance covered while decelerating at <−3 m·s⁻² |
|                              | Moderate-speed acceleration (m) | Distance covered while accelerating at >2 to ≤3 m·s⁻² |
|                              | Moderate-speed deceleration (m) | Distance covered while decelerating at <−2 to ≥−3 m·s⁻² |
| RHIEs                        | RHIEs (#)                 | Count of the number of occasions in which ≥3 qualifying efforts qualifying effort defined as attaining a speed of >5.5 m·s⁻¹, accelerating at >2 m·s⁻², or decelerating at <−2 m·s⁻² are performed over a ≈21 s period |
| Time                         | Duration (min)            | Length of time for any given period             |

*AU = arbitrary units; HSR = high-speed running; LSR = low-speed running; MSR = moderate-speed running; PL = PlayerLoad; SPR = sprinting; TD = total distance; RHIEs = repeated high-intensity efforts.
position and substitution timing. Top-ups for unused substitutes were longer in duration and elicited greater absolute TD and LSR responses, alongside more RHIEs compared with sessions performed by players who had been introduced at 75:00 minutes of match-play or later (all \( p \leq 0.05 \), ES: 0.38–0.40, small). Unused substitutes also accumulated more MSR than substitutes introduced between 60:00–74:59 minutes \( (p = 0.029 \), ES: 0.73 \([0.27–1.20]\), moderate). Irrespective of substitution timing, midfielders produced greater relative TD and PL responses but performed less absolute MSR and fewer high-speed accelerations compared with defenders \( (p \leq 0.05 \), ES: 0.42–0.66, small to moderate). Midfielders also exceeded attackers for relative TD \( (p = 0.023 \), ES: 0.48 \([0.17–0.79]\), small), whereas the responses of goalkeepers did not differ from any outfield position for any variable.

As indicated in Table 3, early-season top-ups lasted longer than mid-season and late-season sessions \( (p \leq 0.05 \), ES: 0.50–0.54, small). Early-season sessions also produced the greatest values for absolute TD, MSR, PL, high-speed and moderate-speed acceleration distance, the number of moderate-speed accelerations, and the number of RHIEs performed \( (p \leq 0.05 \), ES: 0.34–0.76, small to moderate). Compared with mid-season, players during early-season top-ups performed more absolute LSR and high-speed decelerations, covered greater distance while decelerating at high speed, yet recorded lower relative values for TD, PL, and HSR \( (p \leq 0.05 \), ES: 0.40–0.69, small to moderate). Moreover, top-ups conducted early in the season elicited more absolute SPR, alongside an increased number of high-speed accelerations and moderate-speed decelerations, compared with late-season sessions \( (p \leq 0.05 \), ES: 0.44–0.57, small).

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**Table 2**

| Variable | Overall | Unused | 75:00–74:59 min | 60:00–74:59 min | Midfielders | Attackers | Defenders | Goalkeepers |
|----------|---------|--------|----------------|----------------|-------------|-----------|-----------|-------------|
| Duration | Min     | Min    | Min            | Min            | Min         | Min       | Min       | Min         |
| TD       | 17.13 ± 7.44 | 17.76 ± 6.80† | 14.80 ± 8.28† | 16.31 ± 10.46 | 16.24 ± 7.85 | 17.61 ± 8.07 | 18.72 ± 7.36 | 16.28 ± 5.30 |
| LSR      | 1.695 ± 624 | 1.763 ± 587† | 1.504 ± 748† | 1.474 ± 574 | 1.670 ± 647 | 1.697 ± 689 | 1.796 ± 595 | 1.636 ± 496 |
| MSR      | 102.8 ± 18.6 | 101.7 ± 14.8 | 107.7 ± 23.9 | 103.2 ± 32.8 | 108.5 ± 20.4‡ | 99.5 ± 16.9 | 97.8 ± 12.0 | 103.7 ± 21.4 |
| PL       | 361 ± 189 | 377 ± 185§ | 341 ± 210 | 258 ± 132‡ | 338 ± 198# | 357 ± 153 | 433 ± 245 | 338 ± 149 |
| Peak velocity | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ | m·s⁻¹ |
| ACCdist  | 7.0 ± 0.5 | 7.0 ± 0.6 | 7.0 ± 0.4 | 7.0 ± 0.4 | 7.1 ± 0.5 | 7.1 ± 0.5 | 7.0 ± 0.7 | 6.8 ± 0.5 |
| HSR      | 28 ± 15 | 29 ± 16 | 26 ± 15 | 27 ± 11 | 27 ± 14 | 28 ± 15 | 35 ± 18 | 25 ± 12 |
| SPR      | 43 ± 20 | 44 ± 19 | 38 ± 23 | 37 ± 16 | 41 ± 21 | 44 ± 19 | 48 ± 20 | 38 ± 17 |
| ACC#      | 13 ± 6 | 13 ± 7 | 11 ± 7 | 13 ± 5 | 12 ± 6# | 12 ± 6 | 15 ± 7# | 12 ± 6 |
| BAC#      | 15 ± 8 | 15 ± 8 | 13 ± 9 | 12 ± 7 | 14 ± 8 | 15 ± 8 | 17 ± 8 | 13 ± 7 |
| RHIEs    | 6 ± 2 | 6 ± 4‡ | 5 ± 3† | 5 ± 4 | 5 ± 3 | 6 ± 4 | 6 ± 4 | 5 ± 3 |

*ACCdist = acceleration distance; AU = arbitrary units; ACC# = deceleration distance; HSR = high-speed running; LSR = low-speed running; MSR = moderate-speed running; PL = PlayerLoad; RHIEs = repeated high-intensity efforts; SPR = sprinting; TD = total distance; #ACC = number of accelerations; #BAC = number of decelerations.

†Different from unused substitutes.
‡Different from 75:00+ minutes substitutes.
#Different from 60:00–74:59 minutes substitutes.
*Different from midfielders.
Financial support from the EU under the 7th Framework Programme, 2007–2013, through the FP7-PEOPLE-2010-IEF project (grant no. 272511, “Defence System Development Project”).
Although late-season sessions exceeded mid-season for absolute MSR (p = 0.013, ES: 0.67 [0.35–0.99], moderate), greater relative TD, HSR, and PL values were observed during mid-season sessions (all p ≤ 0.05, ES: 0.47–0.69, small to moderate).

Regarding fixture density (Table 3), players recorded higher absolute TD, PL, and LSR values, alongside greater relative LSR, SPR, and PL responses, during top-ups performed when the fixture density was low, compared with moderate (all p ≤ 0.05, ES: 0.34–0.69, small to moderate). Conversely, periods of moderate fixture density exceeded periods of low fixture density relative HSR, the number of high-speed accelerations and decelerations performed, high-speed acceleration distance, and distance covered while decelerating at high and moderate speed (all p ≤ 0.05, ES: 0.37–0.87, small to moderate).

Although greater relative TD, LSR, and PL responses were observed for a low fixture density, top-ups were shorter and produced lesser values for all acceleration and deceleration variables when the fixture density was low, compared with high (all p ≤ 0.05, ES: 0.4–0.107, small to moderate). A high fixture density exceeded a moderate fixture density for session duration, absolute TD, absolute PL, high-speed and moderate-speed acceleration and deceleration distance, and the number of moderate-speed accelerations and decelerations performed (all p ≤ 0.05, ES: 0.40–0.68, small to moderate). By contrast, relative values for TD, HSR, and PL were greater when the fixture density was moderate compared with high (all p ≤ 0.05, ES: 0.39–0.68, small to moderate).

Match location, result, and time of day each influenced certain physical responses (Table 4). Top-ups completed after home matches were longer and elicited greater absolute values for TD, LSR, and HSR, as well as an increased number of moderate-speed accelerations, more RHIEs, and more moderate-speed accelerations.
Table 4
Descriptive statistics for substitutes’ post-match top-up responses, with comparisons between match location, result, and time of day.*

| Variable | Match location | Match result | Time of day |
|----------|----------------|--------------|-------------|
|         | Home | Away | Win | Draw | Loss | Afternoon | Early | Evening |
| Duration min | 18.99 ± 9.24§§ | 15.14 ± 4.02†† | 17.56 ± 8.75 | 15.71 ± 5.19 | 17.25 ± 5.98 | 17.04 ± 7.54 | 15.32 ± 2.71 | 17.79 ± 7.59 |
| TD Absolute (m) | 1859 ± 764§§ | 1521 ± 357† † | 1708 ± 719 | 1658 ± 530 | 1697 ± 492 | 1699 ± 622 | 1594 ± 269 | 1693 ± 684 |
| Relative (m-min⁻¹) | 103.1 ± 20.5 | 102.6 ± 16.3 | 102.1 ± 19.9 | 107.2 ± 13.7 | 101.4 ± 18.6 | 103.8 ± 18.9 | 104.8 ± 12.2 | 98.5 ± 17.4 |
| LSR Absolute (m) | 1.002 ± 637§§ | 0.738 ± 246† † | 0.854 ± 559 | 0.902 ± 498§§ | 0.893 ± 404 | 0.885 ± 504 | 0.677 ± 202 | 0.858 ± 543 |
| Relative (m-min⁻¹) | 50.4 ± 11.8 | 49.5 ± 14.2 | 47.3 ± 12.4 | 55.2 ± 14.6 | 51.4 ± 11.8 | 51.3 ± 13.2|| | 43.7 ± 7.0 | 44.8 ± 11.3# |
| MSR Absolute (m) | 373 ± 225 | 348 ± 140 | 383 ± 222|| | 379 ± 160 | 311 ± 123§ | 379 ± 195†† | 352 ± 108 | 282 ± 146# |
| Relative (m-min⁻¹) | 22.2 ± 11.3 | 23.6 ± 9.1 | 23.8 ± 11.0|| | 24.2 ± 8.6 | 20.3 ± 9.6§§ | 23.8 ± 10.4† † | 22.6 ± 3.3 | 18.8 ± 9.6# |
| HSR Absolute (m) | 447 ± 179§ | 406 ± 163† || | 445 ± 187|| | 363 ± 143§§ | 437 ± 156|| | 410 ± 169†† | 542 ± 113 | 487 ± 181# |
| Relative (m-min⁻¹) | 28.5 ± 15.2 | 27.7 ± 12.2 | 29.4 ± 14.1|| | 26.5 ± 15.9 | 26.8 ± 11.7 | 27.1 ± 13.3 | 36.6 ± 11.9 | 31.5 ± 15.4 |
| SPR Absolute (m) | 36 ± 66 | 28 ± 54 | 26 ± 53|| | 14 ± 29|| | 55 ± 80|| | 25 ± 51† † | 22 ± 17 | 66 ± 88# |
| Relative (m-min⁻¹) | 2.0 ± 3.7 | 1.8 ± 3.6 | 1.6 ± 3.3|| | 1.3 ± 2.9|| | 2.9 ± 4.4|| | 1.6 ± 3.4† † | 1.5 ± 1.3 | 3.3 ± 4.7# |
| PL Absolute (AU) | 175.42 ± 78.48 | 141.83 ± 37.66 | 159.66 ± 72.29 | 153.72 ± 56.21 | 161.82 ± 53.81 | 159.63 ± 64.18 | 149.97 ± 23.00 | 158.59 ± 69.99 |
| Relative (AU-min⁻¹) | 9.63 ± 2.10 | 9.52 ± 1.55 | 9.46 ± 1.92 | 9.82 ± 1.23 | 9.61 ± 2.06 | 9.65 ± 1.86 | 9.98 ± 1.86 | 9.16 ± 1.80 |
| Peak velocity m·s⁻¹ | 7.0 ± 0.5 | 7.0 ± 0.6 | 7.0 ± 0.5 | 7.0 ± 0.7 | 7.1 ± 0.6 | 6.9 ± 0.5† † || | 7.7 ± 1.4# | 7.2 ± 0.5# |
| ACDdist | | | | | | | | |
| High (m) | 30 ± 17 | 27 ± 13 | 30 ± 17 | 26 ± 11 | 27 ± 14 | 28 ± 16 | 41 ± 7 | 28 ± 13 |
| Moderate (m) | 45 ± 23 | 40 ± 16 | 46 ± 23|| | 39 ± 14 | 39 ± 16§ || | 42 ± 20 | 55 ± 13 | 43 ± 19 |
| DCDdist | | | | | | | | |
| High (m) | 10 ± 8 | 9 ± 7 | 11 ± 8|| | 9 ± 5 | 8 ± 6§ || | 9 ± 8 | 12 ± 5 | 10 ± 5 |
| Moderate (m) | 26 ± 16 | 23 ± 11 | 27 ± 16|| | 23 ± 11 | 21 ± 11§ || | 24 ± 14** | 38 ± 8# | 24 ± 11 |
| #ACC | | | | | | | | |
| High (#) | 13 ± 7 | 12 ± 6 | 13 ± 7 | 12 ± 5 | 12 ± 6 | 12 ± 7 | 18 ± 3 | 13 ± 6 |
| Moderate (#) | 16 ± 9† † | 13 ± 6† || | 16 ± 9 | 14 ± 6 | 13 ± 7 | 15 ± 8 | 18 ± 6 | 15 ± 8 |
| #ACC | | | | | | | | |
| High (#) | 6 ± 5 | 5 ± 3 | 6 ± 5|| | 5 ± 3 | 4 ± 4§ || | 5 ± 4 | 5 ± 3 | 5 ± 4 |
| Moderate (#) | 13 ± 8‡ | 10 ± 5 || | 13 ± 8 | 11 ± 5 | 10 ± 6 | 12 ± 7 | 17 ± 3 | 11 ± 7 |
| RHEs | | | | | | | | |
| # | 6 ± 4† † | 5 ± 3† † | 6 ± 4 | 5 ± 3 | 6 ± 3 | 5 ± 4 | 3 ± 1 | 7 ± 4 |

*ACDdist = acceleration distance; AU = arbitrary unit; DCDdist = deceleration distance; HSR = high-speed running; LSR = low-speed running; MSR = moderate-speed running; PL = PlayerLoad; RHEs = repeated high-intensity efforts; SPR = sprinting; TD = total distance; #ACC = number of accelerations; #ACC = number of decelerations.
†Different from home matches.
‡Different from away matches.
§Different from wins.
#Different from draws.
||Different from losses.
‡‡Different from afternoon matches.
**Different from early matches.
††Different from evening matches (for all comparisons, a single symbol indicates differences at the p ≤ 0.05 level, whereas a double symbol denotes differences at the p < 0.01 level).

Decelerations, compared with away matches (all p ≤ 0.05, ES: 0.25–0.89, small to moderate). When the reference team had won the preceding match, players recorded more high-speed decelerations, alongside greater responses for absolute and relative MSR, moderate-speed acceleration distance, high-speed deceleration distance, and moderate-speed deceleration distance, compared with top-ups performed after losses (all p ≤ 0.05, ES: 0.34–0.45, small). Wins and losses each exceeded draws for absolute HSR; relative LSR was higher following draws than following wins, whereas top-ups performed immediately after losses elicited greater absolute and relative SPR responses compared with draws (all p ≤ 0.05, ES: 0.35–0.68, small to moderate). Compared with evening matches, greater absolute and relative MSR and relative LSR values were observed after afternoon fixtures (all p ≤ 0.05, ES: 0.50–0.53, small). Moreover, top-ups conducted after afternoon matches elicited less absolute HSR, less absolute and relative SPR, and lower peak velocities compared with evening matches, while also producing lower peak velocities along with less moderate-speed deceleration distance than early matches (all p ≤ 0.05, ES: 0.43–1.26, small to large).

Discussion
This study quantified the physical demands of professional soccer substitutes during post-match “top-up” conditioning sessions while assessing contextual influences. On average, top-ups lasted for ~17 minutes and elicited ~1.7 km of TD. However, sessions were the longest for unused squad members, who typically produced greater absolute physical responses compared with
Top-ups are typically prescribed with the aim of helping to compensate for deficits in physical loading for individuals who receive either no match-play exposure or substantially less than that of whole-match players (21). In particular, although differences in the availability of resources or fixture scheduling may lead to a substantial between-team variation, providing a HSR stimulus often represents a primary objective during these sessions (21). Players in this study performed ~0.4 km of HSR during post-match top-ups, values that fall substantially below the ~0.8–1.0 km typically accumulated by professional soccer players throughout a 90 minutes match (8,13,30). Given the role of top-ups as a means of offsetting discrepancies in match-play demands, it is unsurprising that unused members of the matchday squad recorded generally greater absolute top-up responses compared with players who had experienced partial match-play (i.e., those substitutes who were deployed during the immediately preceding match). However, acknowledging that any match exposure must also be considered when assessing an individual’s overall match-day loading and that considerable variation may exist in relation to a substitute’s match demands, an existing study of English Championship soccer players indicated that substitutes typically covered just ~0.1 km of HSR after entry onto the pitch (18). Moreover, substitutes may accumulate little or no HSR or SPR during preparatory activities performed before match introduction (17,18), with many practitioners deeming a substitute’s pre-pitch-entry responses to be too minimal to warrant inclusion within assessments of match-day loading (21). As match-play may represent an important stimulus for promoting sport-specific physical adaptations (28,35), the likely reduction in absolute match-day loading for unused or partial-match players compared with their whole-match counterparts has the potential to negatively influence an individual’s adaptive responses, particularly for those who are repeatedly omitted from the starting team over the course of multiple fixtures.

Whereas absolute HSR in this study equated to <50% of whole-match values for players occupying outfield players (8,13,30), relative HSR of ~28.1 m·min⁻¹ far exceeds the ~4.8–10.1 m·min⁻¹ typically recorded across a playing bout for both partial-match and whole-match players (6,8,18). Indeed, such values broadly reflect the relative HSR responses reported during the “peak” 2–3 minutes period of match-play (12,16,19). Although the role of HSR “intensity” in physical preparation and injury management remains to be determined, it may be important for practitioners to consider the potential for differing physiological responses when substantially overloading relative HSR compared with typical match-play demands and to assess the volume of HSR that can be safely accumulated in the limited time available for post-match conditioning (9). Within the context of the overall periodized training program, such decisions may be informed on an individual player basis with reference to factors, such as a player’s ongoing HSR loads and perceived physical development priorities (9).

Large fluctuations in physical loading may increase injury risk among team sports players (14,24,25), whereas the presence of low ongoing loads may exacerbate such effects (11,24,25). As such, if an appropriate volume of top-up training is not performed, a reduction in a player’s match-day demands could promote an increased susceptibility to injury as a consequence of declines in absolute loading over the course of time (9). Acknowledging that the presence of sufficient training and matchplay loads may be vital for developing tolerance to very high-speed efforts (11,25), ensuring that players are regularly exposed to maximum or near-maximum velocity running could represent an important strategy for injury risk reduction (11,25,26). However, as tactical preparations and fatigue management often represent a team’s primary focus during the days between competitive fixtures, the types of drills (e.g., small-sided games) typically adopted during squad training sessions may afford limited opportunities for a player to sprint during a professional soccer season (1,3). Indeed, excluding match-day responses (i.e., typically ~0.2–0.3 km·player⁻¹·match⁻¹ for whole-match players (3,8,13,30)), professional players may at times perform as little as <0.01 km·player⁻¹·week⁻¹ of SPR throughout an entire 7-day microcycle (3). As top-ups in this study elicited just ~0.03 km of SPR and players reached peak velocities of ~7.0 m·s⁻¹, these data highlight the importance of ensuring appropriate SPR exposure during other training sessions throughout the week. Alternatively, or in conjunction, such observations could highlight an opportunity to address current practices by tailoring the design of post-match conditioning sessions to promote greater SPR responses. Notably, increasing a player’s SPR volume could also provide a valuable stimulus for developing explosive physical performance, with improvements in a 40-m sprint and maximum aerobic speed having been observed when professional players performed repeated sprints and high-intensity interval training once per week throughout 10 weeks of the season (15).

Notwithstanding the potential benefits to emphasizing HSR and SPR during top-up conditioning sessions, several practical and logistical considerations may limit what can be achieved during the immediate post-match period. For example, The English Football Association handbook stipulates that activities performed after the conclusion of the match “shall last for no longer than 15 minutes” and gives discretion to ground staff to dictate which areas of the pitch can and cannot be used for this purpose (33). When one considers the likely need for unused substitutes to undertake appropriate warm-up or re-warm-up activity before performing very high-speed activities, alongside the fact that team management staff may wish to deliver tactical debriefing to all squad members immediately after the conclusion of play, the existence of spatial and temporal restrictions could at least partly explain the HSR and SPR responses observed in this study. Indeed, given the limited time often available for post-match top-ups, practitioners may choose to prioritize other stimuli such as developing aerobic capacity, which can be achieved in a more time efficient manner and may be perceived to carry a lower acute injury risk in the circumstances (i.e., when up to ~120 minutes may have elapsed after cessation of the pre-match warm-up). If this approach is taken, it may be important for practitioners to ensure that players are exposed to maximum or near-maximum velocity running elsewhere within the microcycle.

After home matches, top-ups lasted longer and elicited greater values for absolute TD, LSR and HSR, alongside the number of moderate-speed accelerations, RHIES, and moderate-speed decelerations performed, compared with away matches. Such observations may seem unsurprising when one considers that return travel arrangements are likely to represent the main priority for players and team staff after the conclusion of away
matches, particularly when played large distances from home (21). Moreover, post-match activities at away venues could be further limited by a reduced number of traveling support staff, tighter restrictions on pitch usage, and the potential for increased hostility from opposition supporters. Whereas longer session duration might explain the greater absolute responses observed, heightened RHIE, acceleration, and deceleration demands could partly reflect practitioners’ increased freedom to prescribe activities that incorporate changes of direction and potentially small-sided games when sessions are performed on a home turf (1). By contrast, pitch-protection policies at away grounds may limit post-match conditioning strategies to the use of primarily straight-line running drills. Acknowledging that restrictions may also be imposed by home ground staff or competition-wide legislation, it seems likely that more favorable treatment may be afforded to the home team. In support, whereas away sessions lasted for the ~15 minutes stipulated in The Football Association handbook (33), top-ups performed at home extended to ~19 minutes in duration. Irrespective of the underlying reasons, the potential for discrepancies in physical responses after home and away fixtures may need to be borne in mind by practitioners when assessing and prescribing training loads for players who receive limited match-play exposure.

The influence of contextual factors on post-match conditioning is further highlighted by observations that early-season top-ups typically elicited greater absolute demands compared with sessions conducted during the mid-season or late-season periods. Although the primary focus of “topping up” often surrounds addressing deficits in a match-play stimulus on an acute (i.e., per match) basis (21), these data may indicate the importance of considering a player’s physical loading within the context of the overall training cycle. If an individual has experienced particularly high loads during the preceding days or weeks (e.g., having completed multiple matches) or a period of reduced loading is desired within the periodized training program, it may not be appropriate to prescribe a substantial volume of extra conditioning in these scenarios. For example, although the use of substitutions often reflects an effort to positively influence the outcome of a specific match, there may be instances in which certain players are named as substitutes (i.e., as opposed to being selected within the starting team) as part of a “rotation policy” designed to reduce their overall loading or prevent the accumulation of fatigue across a whole squad (20,21). Moreover, acknowledging the potential role of other factors such as the likely deteriorating pitch condition over the course of a season, the generally heightened absolute demands observed during early-season top-up sessions may partly reflect the team’s broader periodization strategy. It seems likely that promoting physical adaptations may represent a primary training objective for a squad during the early stages of the season, whereas the continued accumulation of load over multiple matches means that fatigue management may be increasingly prioritized as the season progresses (2,23).

For certain variables, particularly those relating to acceleration and deceleration responses, top-ups performed during periods of high fixture density elicited greater demands compared with sessions conducted under moderate-density or low-density conditions. Top-ups were also longer in duration when the fixture density was high. Although such observations may seem surprising, these patterns may be attributable to the fact that an increase in fixture congestion typically reduces the amount of whole-team training that can be conducted within a given period (i.e., when travel and recovery considerations may account for a greater proportion of the time between fixtures). Therefore, because overall training demands may be limited when the fixture density is high, greater importance may be attributed to post-match conditioning sessions as an opportunity to elicit a substantial stimulus, particularly for players who rarely feature in the starting team. Notably, fixture congestion may also restrict the volume of technical and tactical training that can be performed throughout the week. Acknowledging that time and space may often be limited during the post-match period, incorporating activities such as small-sided games within top-up sessions may allow practitioners simultaneously to provide stimuli for the development or maintenance of physical capacity and soccer-specific skills.

Midfielders typically accumulate the greatest absolute and relative match-play distances of any playing position (6–8,17,18,27). Such discrepancies seem to suggest in favor of taking a position-specific approach to training prescription and may also warrant consideration in relation to post-match top-ups (31). In support, given the objective of compensating for deficits in loading compared with a player’s typical whole-match demands, it seems appropriate that the physical loads of midfielders may need to be “topped up” to a greater degree than players in other positions (9). That said, although midfielders in this study produced the greatest relative TD and PL values during post-match top-ups, defenders surpassed midfielders for absolute MSR and the number of high-speed accelerations completed. As a position-specific session design was not adopted during the observation period for this study, such heightened relative demands may be attributable primarily to factors such as a greater physical capacity among midfielders (27) or differences in individualized weekly loading targets, as opposed to reflecting conscious differences in training prescription between positional groups.

Although top-ups for outfield players elicited substantially lower absolute running demands compared with those typically observed throughout 90 minutes of match-play, the same may not be true for goalkeepers. Goalkeepers in this study produced similar physical responses to players in outfield positions, accumulating ~0.4 km at >5.5 m·s⁻¹ during post-match top-ups. However, professional goalkeepers may cover just ~0.1 km of HSR throughout a whole match, even when a position-specific HSR threshold of >4.17 m·s⁻¹ is used (37). Given the increased injury risk associated with spikes in an HSR load (10,14), caution must be exercised when goalkeepers participate in post-match conditioning sessions alongside outfield players, particularly for individuals who are unaccustomed to this form of training. Moreover, as match-play may require goalkeepers to perform several position-specific tasks, such as jumps, dives, and high-speed kicking actions (37), the adoption of bespoke top-up strategies that emphasize these explosive actions may help to provide an additional stimulus for the promotion of such crucial adaptations.

Several limitations should be noted when interpreting the findings of this study. Although useful for monitoring specific aspects of external loading, MEMS data in isolation cannot quantify all contributions to a player’s internal and external physical load. Nonetheless, given that top-ups often target specific objectives such as providing an HSR stimulus (9,21), direct measurement of individual external load metrics gives valuable insights into the responses elicited during post-match sessions. Moreover, the use of PL, which represents a three-dimensional measure of instantaneous rate of change in acceleration, may provide an indication of external loading on a more global level.

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Empirical observations suggest that PL is widely used by practitioners as a marker of overall external load, and this variable has demonstrated strong relationships with heart rate and rating of perceived exertion-based training load measures (34). Although the influence of substitution timing was analyzed, this study assessed the responses to top-up conditioning sessions in isolation and did not monitor changes in physical loading over a longer period of time. A player’s training and match-play demands over several days or weeks may be an important factor in determining what constitutes an appropriate degree of “topping up” and may thus influence the responses elicited during post-match sessions. Similarly, as data were collected only from substitutes who performed top-ups after any given match, contextual influences may have been partly obfuscated by the exclusion of instances in which a player or group of players did not undertake post-match conditioning. That said, this study provides novel insights into the match-day top-up conditioning practices of professional soccer substitutes while demonstrating the influence of several contextual variables. Such information may be useful to highlight the barriers currently existing in relation to post-match top-up sessions and could help applied practitioners to assess and then address current practices.

**Practical Applications**

This study quantified the physical responses of professional soccer substitutes during post-match top-up conditioning sessions. The importance of top-up sessions is highlighted by the fact that because team training programs are often designed on the basis that match activities are expected to represent a substantial contributor to a player’s physical loads during a season, there exists the potential for individuals who are repeatedly omitted from the starting team to experience reductions in loading compared with whole-match players. Notably, such declines may be associated with decreases in sport-specific physical performance adaptations and an increased risk of sustaining non-contact soft tissue injury. As several contextual variables, such as substitution timing, match location, result, time of day, playing position, fixture density, and the stage of the season, influence the demands of post-match sessions, practitioners should consider the presence of practical or logistical barriers when designing match-day top-ups. Moreover, because direct and indirect restrictions on the time and space available for training may limit what can be achieved during the immediate post-match period, management and support staff may decide that performing top-up sessions the next day or modifying training prescription throughout a microcycle (e.g., to ensure maximum or near-maximum velocity running elsewhere during the week) may offer greater flexibility to safely achieve the desired volume and intensity of stimulus. That said, the suitability of this approach must be assessed on a case-by-case basis with reference to factors such as player and staff psychology, existing training and recovery demands, fixture scheduling/travel arrangements, and the availability of resources.

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