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Re-examination of the post half-time reduction in soccer work-rate

Ric Lovell[a,*], Stephen Barrett[b], Matthew Portas[c], Matthew Weston[c]

[a] School of Science and Health, University of Western Sydney, Australia
[b] Department of Sport, Health and Exercise Science, University of Hull, UK
[c] Department of Sport & Exercise Sciences, Teesside University, UK

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ABSTRACT

Objectives: To re-examine the work-rate of soccer players immediately after a passive half-time interval with an alternative approach to data reduction and statistical contrasts.
Design: Time–motion analysis data (5 Hz global positioning system), were collected from 20 elite youth players (age: 17 ± 1 years) during 21 competitive league fixtures (5 ± 3 matches per player).
Methods: Physical performances were categorised into total distance covered, total low-speed running (0–14.9 km h^{-1}) and total high-speed running (15.0–35.0 km h^{-1}). These dependent variables were subsequently time averaged into pre-determined periods of 5-, 15- and 45-min duration, and expressed in relative (m min^{-1}) terms to allow direct comparisons between match periods of different lengths. During the 15-min half-time interval players were passive (seated rest).
Results: There was a large reduction in relative total distance covered (effect size – standardised mean difference – 1.85), low-speed running (effect size −1.74) and high-speed running (effect size −1.37) during the opening 5-min phase of the second half (46–50 min) when compared to the first half mean (0–45 min). When comparing the 51–55 and 56–60-min periods, effect sizes were trivial for relative total distance covered (effect size −0.13; −0.04), low-speed running (effect size −0.10; −0.11) and small/trivial for high-speed running (−0.39; 0.11).
Conclusions: Using a more robust analytical approach, the findings of this study support and extend previous research demonstrating that players work-rate was markedly lower in the first 5-min after a passive half-time interval, although we observed this phenomenon to be transient in nature. Time–motion analysts might re-consider their data reduction methods and comparators to distinguish within-match player work-rate trends.

1. Introduction

The 15-min half-time interval (HT) in professional soccer is typically a passive period in which players engage in tactical briefings, rehydrate, and where necessary receive medical attention. A growing body of evidence has demonstrated reduced high-speed running (HSR) activities immediately after the half-time interval, when compared to the opening 5- or 15-min period of the first half.[1–3] This decrement in physical performance has been largely attributed to the role of muscle temperature, with decrements of 1.5–2.0 °C recorded following a passive HT, which have been associated with performance reductions in powerful soccer-specific actions.[4,5] However, the reduced work-rate observed in soccer match-play may represent a statistical artefact, rather than any physiological impairment.

As motion analysis technology and data processing systems have evolved, researchers have been able to measure within-match physical performance by categorising time–motion data into pre-determined periods. Originally, between-half (45-min) comparisons were made,[6] and more recently it has become commonplace to compare the 15-min periods to make inferences regarding cumulative player fatigue.[1,2] Furthermore, contemporary studies have identified the 'temporary fatigue' phenomenon in elite-level soccer match-play, by using pre-determined 5-min periods.[1,2] To our knowledge, the arbitrary sampling frequencies adopted previously have not been rationalised, but are convenient divisors of a 90-min match.

A post-HT decrement in HSR is observed when comparing the opening 15-min periods of each half for elite players[1,3] and match referees.[3,7] However, drawing conclusions about sub-optimal preparation as a consequence of a passive HT should be made with caution. Firstly, the sampling of data over a 15-min period is considered inadequate to monitor the intricacies of the work-rate pattern.[8,9] This was demonstrated by Mohr et al.[2] who observed a decreased HSR distance in the first 5-min of the

* Corresponding author.
E-mail address: R.Lovell@uws.edu.au (R. Lovell).

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second half, compared to the corresponding phase of the first half, yet this difference was not observed in the 6–10 min period. Secondly, this initial match period may not provide an appropriate reference point against which comparisons are drawn, since the first few minutes of match-play are typically frantic in nature and consequently the tempo is at its most intense.[8,10] Thirdly, studies reporting lower physical match performances at the start of the second half have relied on null hypothesis testing. Yet in sports performance research it is not whether there is an effect, but how big the effect is and use of the *P* value alone provides no information about the direction or size of the effect or the range of feasible values.[11]

Therefore, the purpose of the current study was to re-examine the work-rate of players after a passive half-time interval by (1) using an alternative pre-determined match period as the criterion, (2) using 5-min segments to analyse the players' physical performances post-HT, and (3) utilising analysis techniques that express, both quantitatively and qualitatively, the magnitude of the effect. We hypothesised that our alternative analytical approach would provide a more sensitive and robust evaluation of the post-HT decrement in soccer work-rate, which may have implications for in-game player support strategies.

2. Methods

Twenty outfield players (age: 17 ± 1 years; height: 1.81 ± 0.05 m; body mass: 74.5 ± 7.4 kg; VO_{2max}: 61 ± 6 ml kg^{-1} min^{-1}) that represented an English Championship youth team (under 18s) were used in this study. This sample included 4 wide defenders, 4 central defenders, 3 central midfielders, 3 wide midfielders, and 6 strikers. Each player was post-adolescent with an average of 3.2 (±0.4) years after peak height velocity, as calculated according to Mirwald et al.[12] Players trained on a 'full-time' professional basis for 13.5 h per week, which included 7 soccer training sessions, 2 strength training sessions, 2–3 conditioning sessions, and one competitive fixture each week. The players were unaware of the aims of the study, which had ethical clearance from the departmental committee, and obtained written and verbal consent prior to participation, in accordance with the principles outlined in the Helsinki Declaration.

The physical match data were collected from 21 competitive 'home' and 'away' league fixtures during the 2008/2009 and 2009/2010 seasons (giving a total of 111 match observations). Players wore a 5 Hz global positioning system (GPS; MinimaxX, Catapult Innovations, Canberra, ACT, Australia), which was harnessed between the scapulae in a customised undergarment to reduce movement artefact.

Recent work investigating the performance of 5 Hz GPS technology has found it to be reliable (CV = 2–5%) and valid (SEE = 1–2%) for measurement of total distance in soccer-specific activity.[13] Additionally, 5 Hz GPS can be used to measure the cumulative distance of prolonged high-intensity bouts of multi-directional soccer activity with both good reliability (CV = 3.5%) and validity (SEE = 1.5%).[13] Although recent research has shown only moderate agreement ($r = .54$) between 5 Hz GPS and a semi-automated image tracking system,[14] validity testing of image-tracking systems has not been subject to the same experimental rigour that has been applied to GPS, and as such a gold-standard measure of work-rate in soccer match-play is absent.

Players wore the same GPS unit in each game to avoid between-unit measurement error and data analysis was performed post-match. Injury time was excluded in this study, as were any incidences where the player did not complete the full game or changed tactical position during match-play. In accordance with manufacturers instructions, match cases were only included if the GPS unit was detected by a minimum of 6 satellites throughout.

Prior to the start of the match, the players participated in a standardised 25-min warm-up which included light-jogging, dynamic stretching, technical drills and repeated high-intensity exercises. On completion of the pre-match warm-up, the coach provided final tactical and motivational instructions in the dressing rooms during a 10-min interval immediately prior to kick-off. To avoid any interference with the satellite signal the GPS units were removed and left pitch-side during the 15-min HT interval whilst the players routinely returned to the changing rooms. The interval was characterised by passive (seated) rest and *ad libitum* fluid replenishment, whilst receiving technical information from the coaching staff. Where any of these outlined procedures were not adhered to, due to facility or situational factors, the data were excluded from the current study.

The distances covered by the players were categorised into arbitrary velocity bands, which included total distance covered (TD), total low-speed running (LSR: 0–14.9 km h^{-1}) and high-speed running (HSR; 15.0–35.0 km h^{-1}). We computed the mean for each variable from the set of repeat matches for each player (5 ± 3 matches per player). The HSR inception was set at 15 km h^{-1} as recommended in the absence of individualised threshold prescription.[15] However, we did not consider further sub-categorising the velocity data due to the player-dependent velocities of transitions between movement patterns,[16] and because sprinting reliability and validity in discreet bouts with 5 Hz GPS is questionable.[13] Based on peak speed assessments during pilot work on this sample population, we set an upper-limit of 35.0 km h^{-1} for HSR, to arrest non-physiological running speed values reported in other studies using this technology.[14]

The distances covered by the players were also categorised by pre-determined periods of 5, 15 and 45 min duration and are expressed in relative (m min^{-1}) terms to enable direct comparisons of player work-rate between pre-determined match periods of different lengths.

The post HT work-rate was examined by comparing the relative mean distance covered (m min^{-1}) in the first half (0–45 min) to that of the opening 15-min of the second half, using both 5- (46–50, 51–55, 56–60 min) and 15-min (46–60 min) pre-defined match-periods. We hypothesised that using the 0–45 min as our criterion sampling period would attenuate the impact of the high-tempo start to the game, yet preclude the onset of fatiguing mechanisms, since 45 min of actual or simulated match-play has not impaired sprint performance,[4] or dynamic strength.[17] Furthermore, muscle glycogen stores are still relatively high at HT,[18] dehydration is mild (−0.7% body mass)[19] and whilst the core body temperature increases significantly during the first half of match-play (38.5–39.0 °C)[4,19], this degree of thermal strain is not indicative of fatigue associated with hyperthermia (~40 °C)[20]. Whilst equally arbitrary, we considered that the first 45 min of match-play would provide a more representative sample of typical player work-rate upon which to base subsequent inferences of reduced physical performance. The 'frantic' opening 15 min should however be encompassed in any within-match analysis comparator to avert under-estimation of the match demands.

Data are presented as the mean (SD) and all analyses were performed on the log transformed data. A priori, we defined the minimal practically important difference as 0.2 between-subject standard deviations. Inference was based on the disposition of the confidence interval for the mean difference to this smallest worthwhile effect; the probability (percent chances) that the true population difference between first and second half is substantial (>0.2 SDs) or trivial was calculated. These percent chances were qualified *via* probabilistic terms assigned using the following scale: <0.5% most unlikely or almost certainly not,