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The influence of fixture congestion on physical performance response to U23 soccer match-play

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ABSTRACT

This study sought to examine differences in measures of intense periods of physical performance during competitive match-play, between one-match (1 match weeks) and two-match microcycles (2 match week). 1, 3 and 5 min "peak" and mean averages for total distance (TD), high-speed running (HSR) and metabolic power (MP) were analysed for each 15 min period of match-play. Linear mixed models were employed to examine the differences in dependent variables for each method of measurement between the 1 and 2 game microcycles. No differences were reported for "peak" values for all epoch lengths, however, results revealed significantly reduced "average" values, during periods of fixture congestion, for 1, 3 and 5 min epochs for average TD, and 3 min epochs for average HSR towards the end of the match (75–90 min split). There was, however, a trend for the opposite response to occur in the 60–75-min period. The current data suggests that players potentially display altered pacing strategies during periods of fixture congestion, with these observed responses being dependent on sampling method and epoch length.

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Congested matches; fatigue; team sports; global positioning systems

Introduction

Competitive soccer commonly requires players to compete in multiple games within a 1-week microcycle (Kelly et al., 2019; Malone et al., 2015). Competing in numerous competitive matches, which require repeated high-intensity actions, within a 1-week microcycle leaves limited recovery time between matches, exacerbating the potential for residual fatigue (Jones et al., 2019; Kelly et al., 2019), leading to reduced physical performance during competitive matches, and increased risk of injury (Carling et al., 2011; Dellal et al., 2015; Dupont et al., 2010; Jones et al., 2019).

Presently, research into the impact of fixture congestion on physical performance during soccer match-play has produced equivocal results (Carling et al., 2015; Dupont et al., 2010; Julian et al., 2021). Julian et al.'s (2021) recent systematic review suggests no changes in total distance during congested schedules; however, some studies have identified differences in physical demands associated with different locomotion thresholds (Carling et al., 2011), thus suggesting that the way in which the total

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distance is accumulated may differ. These observed differences may be a result of methodological differences across studies, for example considering demands across smaller epochs. Indeed, initial research sought to examine the impact of fixture congestion on physical performance via the examination of match average data (e. g. 90 min) and first and second half (e.g. 45 min) averages, thus limiting the sensitivity in the observed differences. More recently, Jones et al. (2019) explored the differences in physical performance, during soccer match-play, between 1, 2 and 3 match microcycles, when partitioned into 15-min epochs (e.g., 0–15, 16–30, 31–45, etc.). Jones et al. (2019), reported differences in physical performance measures of locomotive activity across the within-match 15-min epochs, recorded across matches in a weekly microcycle. Consequently, Jones et al. (2019) suggested that players may "consciously" adopt pacing strategies in which volumes of lower-intensity activity are mitigated in an attempt to maintain the required high-intensity outputs (Julian et al., 2021).

Competitive soccer match-play, and particularly the physical performance outputs, are known to be influenced by the ever-changing contexts, experienced within (Sparks et al., 2017) and between games (Doncaster & Unnithan, 2019). Within matches, style of play, tactics, formations, score-line as well as temporal and residual fatigue are all contextual factors which may impact upon a player's physical performance. As such, reducing the extent to which these contextual factors can impact upon the physical outputs is warranted. This may be achieved through the assessment of players' peak physical outputs throughout the duration of a competitive match, via the application of smaller (1, 3 and 5 min) epoch analysis, within each pre-defined 15-min epoch. Thus, assessing a player's ability to maintain or reproduce intense bouts of physical performance in successive matches (in which the variance is potentially reduced), may yield further insights into the impact of fixture congestion on players' ability to perform intense bouts of physical activity during soccer match-play. Furthermore, the data obtained from this analysis is likely to be more beneficial for programming physical conditioning drills (e.g. small-sided games), than whole-game data. Indeed, as shown in the work of Lacome et al. (2018), data from smaller periods of activity (i.e. 1, 3 and 5 min) can be modelled using a power law relationship, thus increasing specificity of training prescription.

Notably, the ability to maintain, repeat and perform bouts of high-intensity activity is a pre-requisite for high-level soccer match-play (Barnes et al., 2014; Julian et al., 2021). Therefore, while research suggests high-intensity activity is maintained via a reduction in low-intensity activities during periods of fixture congestion (Jones et al., 2019; Julian et al., 2021), the averaging of physical performance data across longer time epochs (i.e. 15 min) may obscure players' abilities to maintain acute bouts of "peak" physical activity, during periods of fixture congestion. Consequently, a more in-depth analysis of the peak-demands experienced during competitive match-play, throughout a 90-min match, may provide an indication as to whether players are able to meet (and maintain) the acute (intense) demands of competitive soccer match-play, when competing in periods of fixture congestion. Therefore, the purpose of this study was to analyse and compare the physical match demands of professional U23 footballers during 1, 3 and 5 min epochs for each 15 min split of competitive match-play, between 1 game and 2 game microcycles.

Materials and methods

Participants

Thirty outfield players who competed within the respective Elite Player Performance Plan (EPPP), Category 1 Football Academy, Under 23 team were included in the study. Due to the potential for pacing strategies relating to players that are substituted (Waldron & Highton, 2014), only those who played for the entirety of each match were included for further analysis. As a result, a total of 168 separate, physical match profiles (mean = 6, range = 1–16 individual match profiles), from 20 competitive matches, were recorded during the 2017/18 competitive season. Matches were categorized into two separate categories, 1 game microcycles and 2 game microcycles. One game microcycles were defined as matches in which one competitive game was performed within the 7-day microcycle, revealing 137 match profiles. Two game microcycles were defined as matches in which a match was completed, by the respective individual, in the subsequent 4 days to the current match, for which only the second match was included, revealing 31 match profiles. Throughout, players' match activities, including total distance (TD), high-speed running (HSR: ≥ 19.8 $km \cdot h^{-1}$) and Metabolic Power (MP) were recorded using 10 Hz devices with incorporated GPS receivers and MEMS technology (Viper Units, STATSports, Newry, Ireland). Metabolic Power provides an estimation of the energy demands of the acceleration and deceleration events undertaken during competition and was regarded as the metres covered above a threshold of 25.5 $W \cdot Kg^{-1}$. Total distance provides a measure of the volume of movement undertaken, whereas measures of HSR and MP provide an indication of the intensity of competitive match-play, with research showing a positive relationship between coaches' ratings of match performance and HSR (Bauer et al., 2017). Moreover, MP takes into consideration players' metabolic demands for high-speed accelerations and decelerations (Coutts et al., 2015), which may be missed if a single measure of locomotor activity (i.e. HSR) is employed. Indeed, analysis of both HSR and MP provides a more detailed insight into the composition of the intense activity which a player performs (Doncaster et al., 2019). Data arose from the routine monitoring procedures employed within the respective club, with permission provided by the club and ethical approval granted from the local University's Department and Research Ethics Committee (SPA-REC-2018-314).

Design and procedures

Due to EPPP requirements for player monitoring during both training and competitive matches, all players were habituated with the devices and had extensive experiences of undertaking sport-specific activities and competed regularly while wearing GPS units, with integrated MEMS technology. All matches were preceded by a standardized 25 min warm-up, which commenced approximately 40 min before kick-off and consisted of straight-line running and dynamic stretching of progressive intensity, followed by moderate and high intensity running incorporating changes of direction, before finishing with possession-based ball-work, which was interspersed with short periods of high-intensity activity. The units were fitted in a purpose made vest, leaving the units placed between the scapulae of each player during competitive match play. All units were switched on approximately 45 min before kick-off, allowing for an appropriate satellite signal to be achieved (Malone et al., 2017). After each match, minute-by-minute match profiles were downloaded and analysed using STATSport Viper Software (firmware 2.7.1.83), with confirmation of >6 satellites (an appropriate signal) being connected and the horizontal dilution of position (HDOP) being less than 1 (Malone et al., 2017). The minute-by-minute match profiles for TD, HSR and MP were then extracted and inputted into a custom designed Microsoft Excel spreadsheet, to calculate the different epoch lengths. For each of the variables, 1, 3 and 5 min peak and mean averages were obtained using minute by minute data sets. Given the reported discrepancies between fixed and rolling sampling methods within the literature (Cunningham et al., 2018; Doncaster et al., 2019; Varley et al., 2012), the rolling sampling method was used for both 3 and 5 min epoch analysis. Indeed, Doncaster et al. (2019), Cunningham et al. (2018), and Varley et al. (2012) demonstrated that rolling averages provide a more accurate representation of the (acute) peak demands during competitive match-play, while pre-defined epochs may lead to an underestimation of the peak demands of competitive match-play. The mean average for TD, HSR and MP, for each epoch length (1, 3 and 5 min) were calculated as the sum total of each 15 min split, divided by the respective number of epochs. Finally, to provide a more in-depth analysis of the potential impact fixture congestion has upon players' physical performance during soccer match-play, peak and average values were obtained for each 15 min split (0–15, 16–30, 31–45, 46–60, 61–75 and 76–90 min).

Despite the known within-game (Sparks et al., 2017) and between-game (Doncaster & Unnithan, 2019) variance in the physical demands of soccer match-play, the GPS and MEMS technology (STATsports, Viper) have been shown to be reliable and valid when measuring distance and peak speed during standardized sport related activities (Beato et al., 2018). During these standardized activities, Beato et al. (2018) reported high levels of reliability, showing "small" coefficients of variation (CVs) of 1.6% (90% CI = 1.3–2.3), 0.8% (0.7–1.2), 0.4% (0.3–0.5) and 0.7% (0.5–0.9) for running distance, sport-specific distance, 20 m sprint distance and 20 m peak speed, respectively. Moreover, the validity of these units was reported to be "good" with absolute errors of 7.9 ± 7.2 m, 3.5 ± 1.5 m, 20.2 ± 0.3 m and 0.40 ± 0.45 $km{\cdot}h^{-1}$, for 400-m running trial, 128.5-m sport-specific circuit, 20-m sprint and peak speed. Nevertheless, while GPS and MEMs devices have been shown to be reliable and valid the within-game and between-game variance should also be considered when utilizing this technology during competitive match-play.

Statistical analysis

Linear mixed models (LMM) were used to examine the temporal (between 15 in splits) differences in the dependent variables (e.g. TD, HSR and MP) recorded across the different sampling epochs between 1 and 2 match weekly microcycles. A LMM was utilized to overcome the assumption of independence, and also because of the flexibility that this method has in accounting for the altering sample sizes between groups with repeated measures (Field, 2013). Before running the LMM, basic variance components analysis was performed, on each dependent variable, to calculate the intraclass correlations (ICC) of the random factors of *player* and *game* to determine if any contributed significant variance. Given the large sample sizes, Wald Z statistics were utilized to test the null hypothesis that the population variance is zero, if rejected the proposed random factors were included in subsequent larger models. The covariance structure of the random factors was set to variance components in all models. Model fit was assessed using Akaike's information criterion (AIC). For each dependent variable, AIC revealed the model that best fit the data utilizing the first order auto-regressive (AR-1) repeated covariance structure for the repeated measures. The fixed effects and their interactions in each model included games per week (1 or 2 game microcycles) and time (0–15, 16–30, 31–45, 46–60, 61–75 and 76–90). All models estimated parameters using the maximum likelihood method. Where appropriate, Bonferroni adjusted post hoc analyses and the respective 95% confidence intervals (95% CI) of the differences were reported. Unless otherwise stated, data is presented as means and standard error (SE), with mean differences (*Mdiff*) presented as a measure of effect size where appropriate. All statistical procedures were carried out using IBM SPSS Statistics (Version 25, Chicago, IL, USA), with two-tailed significance being accepted at $P < 0.05$.

Results

Variance calculations

Table 1 depicts the ICC's (%) of the random factors accounted for in the LMM. Where the random factors of player and game contributed significant variances to the data they were subsequently included as random factors in the larger hierarchical models.

Peak total distance

There was no significant congestion by time interaction for the 1-min ($P = 0.941$) peak TD data. There was also no significant main effect for congestion for the 1-min ($P = 0.876$) fixed peak total distance data and for the 1-min peak total distance data ($P = 0.423$) (Table 2). There was no significant congestion by time interaction for the 3-min ($P = 0.921$) and 5-minute ($P = 0.425$) peak total distance data. There was also no significant main effect for congestion for the 3-min ($P = 0.868$) and 5-min ($P = 0.993$) peak TD data. There was however a significant ($P < 0.001$) main effect for time for all peak TD data, with a reduction in peak TD as the match progressed.

Table 1. The ICC's (%) of each random factor for the TD, HSR and MP data for each analysis method. *represents significant determinant of variance within the linear mixed model ($P < 0.05$).

	TD		HSR		MP	
	Player (%)	Game (%)	Player (%)	Game (%)	Player (%)	Game (%)
Peak 1-min	31.1*	4.0*	16.8*	2.0	7.4	15.2*
Peak 3-min	34.3*	4.7*	26.2*	2.6	22.2*	19.4*
Peak 5-min	35.3*	6.5*	23.2*	3.3*	26.1*	19.7*
Average 1-min	27.8*	6.6*	27.9*	3.9*	24.0*	19.4*
Average 3-minu	28.1*	7.2*	28.2*	3.2	28.1*	21.5*
Average 5-min	26.3*	7.5*	26.0*	3.2	26.2*	19.6*

Table 2. TD (m) data recorded during each epoch for one and two games per week microcycles.

	One game microcycle						Two game microcycle					
	0–15	15–30	30–45	45–60	60–75	75–90	0–15	15–30	30–45	45–60	60–75	75–90
Peak 1-min	180 ± 10	162 ± 10	165 ± 10	172 ± 10	168 ± 10	172 ± 10	176 ± 17	167 ± 17	168 ± 17	168 ± 17	165 ± 17	162 ± 17
Peak 3-min	442 ± 12	403 ± 12	417 ± 12	415 ± 12	402 ± 12	402 ± 12	429 ± 19	406 ± 19	419 ± 19	416 ± 19	403 ± 19	394 ± 19
Peak 5-min	685 ± 15	630 ± 15	634 ± 15	642 ± 15	611 ± 15	615 ± 15	669 ± 22	622 ± 22	654 ± 22	648 ± 22	622 ± 22	602 ± 22
Average 1-min	118 ± 2	108 ± 2	109 ± 2	107 ± 2* ↓ (*Mdiff = 6; CI = −11 to −1)*	104 ± 2	103 ± 2	121 ± 3	109 ± 3	113 ± 3	113 ± 3* ↑	106 ± 3	92 ± 3* ↓ (*Mdiff = 11; CI = −16 to −6)*
Average 3-min	357 ± 6	323 ± 6	328 ± 6	329 ± 6	313 ± 6* ↓ (*Mdiff* = 19; CI = −33 to −4)	302 ± 6	363 ± 9	325 ± 9	339 ± 9	334 ± 9	331 ± 9* ↑	269 ± 9* ↓ (*Mdiff* = 35; CI = −49 to −20)
Average 5-min	598 ± 10	539 ± 10	547 ± 10	548 ± 10	524 ± 10* ↓ (*Mdiff* = 28; CI = −55 to −1)	506 ± 10	605 ± 15	540 ± 15	565 ± 15	556 ± 15	552 ± 15* ↑	459 ± 15* ↓ (*Mdiff* = 47; CI = −74 to −20)

* denotes a significant difference between microcycle conditions (one and two game microcycles) for the respective 15 min epoch. ↓ represents a significantly lower value. ↑ represents a significantly higher value. Mean difference (*Mdiff*) and 95% confidence intervals (CI) for differences are presented for all significant interactions.

Average total distance

Table 2 displays a significant congestion by time interaction for the 1-min(P < 0.001) average TD data. In support of the interactions, there was also a significant (P < 0.001) main effect for time observed for the 1-min average TD data. However, there was no significant main effect for congestion for the 1-min(P = 0.640) average total distance data. In addition, analysis identified a significant congestion by time interaction for the 3-min (P < 0.001) and 5-min (P = 0.001) average TD data. In support of these interactions, there was also a significant (P < 0.001) main effect for time observed for all average TD data, with a reduction in average TD as the match progressed. However, there was no significant main effect for congestion for the 3-minu (P = 0.750) and 5-minu (P = 0.765) average TD data.

Peak high-speed running

There was no significant congestion by time interaction for the 1-minu (P = 0.255) peak HSR data. There was also no significant main effect for congestion (P = 0.985); however, there was a main effect for time (P = 0.046). Similarly, there was no significant congestion by time interaction for the 3-min (P = 0.249) and 5-min (P = 0.189) peak HSR data. There was also no significant main effect for congestion for either the 3-min (P = 0.701) or 5-minute data (P = 0.941). A main effect for time was identified for both the 3- (P = 0.006) and 5-minu (P = 0.005) peak HSR data, with a reduction in 3- and 5-minu peak HSR towards the end of the match (Table 3).

Average high-speed running

Analysis revealed no significant congestion by time interaction for the 1-minu (P = 0.221) average HSR data. There was also no significant main effect for congestion (P = 0.983); however, there was a main effect for time (P = 0.033). There was a significant congestion by time interaction for the 3-minu (P = 0.009) average HSR data, but not for the 5-min average HSR data (P = 0.053). No significant main effect for congestion for either the 3-min (P = 0.280) or 5-min (P = 0.388) average HSR data was revealed. There was a significant main effect for time observed for both the 3-minu (P < 0.001) and 5-minu (P < 0.001) average HSR data, with a reduction in 3- and 5-minu peak HSR towards the end of the match (Table 3).

Peak metabolic power

No significant congestion by time interaction for the 1-minu (P = 0.864) peak MP data was identified. There was also no significant main effect for congestion (P = 0.497); however, there was a main effect for time (P = 0.004). There was no significant congestion by time interaction for the 3-min (P = 0.352) and 5-minute (P = 0.135) peak MP data. There was also no significant main effect for congestion for either the 3-min (P = 0.733) or 5-minu data (P = 0.858). There was a main effect for time identified for both the 3- (P < 0.001) and 5-minu (P < 0.001) peak MP data, with a reduction in 3- and 5-minu peak MP towards the end of the match (Table 4).

Table 3. HSR (m) data recorded during each epoch for one and two games per week microcycles.

	One game microcycle						Two game microcycle					
	0–15	15–30	30–45	45–60	60–75	75–90	0–15	15–30	30–45	45–60	60–75	75–90
Peak 1-min	34 ± 2	32 ± 2	35 ± 2	38 ± 2	34 ± 2	35 ± 2	33 ± 3	36 ± 3	35 ± 3	39 ± 3	36 ± 3	29 ± 3
Peak 3-min	52 ± 3	47 ± 3	53 ± 3	56 ± 3	50 ± 3	50 ± 3	48 ± 5	51 ± 5	54 ± 5	57 ± 5	52 ± 5	41 ± 5
Peak 5-min	38 ± 2	33 ± 2	36 ± 2	39 ± 2	34 ± 2	32 ± 2	38 ± 4	39 ± 4	41 ± 4	41 ± 4	36 ± 4	24 ± 4
Average 1-min	34 ± 2	33 ± 2	36 ± 2	38 ± 2	34 ± 2	35 ± 2	34 ± 3	37 ± 3	35 ± 3	39 ± 3	36 ± 3	28 ± 7
Average 3-min	24 ± 1	20 ± 1	22 ± 1	24 ± 1	21 ± 1* ↓ (*Mdiff* = −4; CI = −8 to 0)	19 ± 1* ↑	23 ± 2	23 ± 2	24 ± 2	25 ± 2	24 ± 2* ↑	14 ± 2* ↓ (*Mdiff* = −4; CI = −8 to −1)
Average 5-min	41 ± 2	34 ± 2	36 ± 2	40 ± 2	34 ± 2	32 ± 2	39 ± 4	39 ± 4	41 ± 4	41 ± 4	41 ± 4	26 ± 4

* denotes a significant difference between microcycle conditions (one and two game microcycles) for the respective 15 min epoch. ↓ represents a significantly lower value. ↑ represents a significantly higher value. Mean difference (*Mdiff*) and 95% confidence intervals (CI) for differences are presented for all significant interactions.

Table 4. MP (m) data recorded during each epoch for one and two games per week microcycles.

	One game microcycle						Two game Microcycle					
	0–15	15–30	30–45	45–60	60–75	75–90	0–15	15–30	30–45	45–60	60–75	75–90
Peak 1-min	40 ± 2	35 ± 2	36 ± 2	37 ± 2	34 ± 2	35 ± 2	37 ± 3	32 ± 3	36 ± 3	36 ± 3	33 ± 3	34 ± 3
Peak 3-min	82 ± 3	73 ± 3	73 ± 3	74 ± 3	69 ± 3	67 ± 3	75 ± 5	68 ± 5	74 ± 5	75 ± 5	68 ± 5	71 ± 5
Peak 5-min	121 ± 4	106 ± 4	104 ± 4	107 ± 4	98 ± 4	92 ± 4	108 ± 7	100 ± 7	104 ± 7	108 ± 7	101 ± 7	102 ± 7
Average 1-min	18 ± 1	16 ± 1	15 ± 1	15 ± 1	14 ± 1	13 ± 1	17 ± 1	15 ± 1	15 ± 1	15 ± 1	15 ± 1	15 ± 1
Average 3-min	55 ± 2	47 ± 2	46 ± 2	47 ± 2	43 ± 2	38 ± 2	49 ± 3	44 ± 3	45 ± 3	46 ± 3	44 ± 3	43 ± 3
Average 5-min	91 ± 3	79 ± 3	76 ± 3	79 ± 3	73 ± 3	65 ± 3	82 ± 5	74 ± 5	74 ± 5	76 ± 5	72 ± 5	71 ± 5

* denotes a significant difference between microcycle conditions (one and two game microcycles) for the respective 15 min epoch. ↓ represents a significantly lower value. ↑ represents a significantly higher value. Mean difference (*Mdiff*) and 95% confidence intervals (CI) for differences are presented for all significant interactions.

Average metabolic power

There was no significant congestion by time interaction for the 1-min ($P = 0.137$) average MP data. There was also no significant main effect for congestion ($P = 0.876$); however, there was a main effect for time ($P < 0.001$). There was also no significant congestion by time interaction for the 3-minu ($P = 0.105$) average MP data. There was also no significant main effect for congestion ($P = 0.688$); however, there was a main effect for time ($P < 0.001$). Similarly, there was no significant congestion by time interaction for the 5-minu ($P = 0.177$) average MP data. There was also no significant main effect for congestion ($P = 0.529$); however, there was a main effect for time ($P < 0.001$) for all MP data, with a reduction in peak TD as the match progressed.

Discussion

This study analysed and compared the physical match demands of professional academy footballers during 1, 3 and 5 min epochs for each 15 min split of competitive match-play, between 1 game and 2 game microcycles (periods of fixture congestion). This paper expands upon the current literature by examining whether periods of fixture congestion have an impact upon a player's ability to reproduce and maintain their physical activity during periods of fixture congestion. Results demonstrate that there were no differences between 1 game microcycles and periods of fixture congestion (2 game microcycles) for measures of 1, 3 and 5 min peak TD, peak HSR and peak MP, suggesting that players are able to maintain acute bouts of "peak" physical performance, during periods of fixture congestion. Analysis of average values did, however, identify a significant reduction in measures of TD for 1, 3 and 5 min epochs, within the 75–90 min, during periods of fixture congestion. For measures of HSR, only 3 min average values for the 75–90 min split were shown to be significantly reduced, during periods of fixture congestion, and no differences were found for measures of MP. During the 60–75 min split average TD and HSR values displayed a tendency to be greater during periods of fixture congestion, with 1, 3 and 5 min epochs displaying significantly greater values for TD during the 60–75 min, and 3 min epochs displaying significantly greater values for HSR, during the same period.

To the authors' knowledge, this is the first study to examine whether periods of fixture congestion affect a players' ability to perform intense bouts of physical activity during competitive match-play. Irrespective of epoch length (1, 3 or 5 min), examination of TD, HSR and MP during acute bouts of intense ("peak") physical performance was found to be comparable between 1 and 2 game microcycles, across all 15 min splits of competitive soccer match-play. Current data suggest that highly trained soccer players can maintain and reproduce intense bouts of physical performance during periods of fixture congestion. Consequently, analysis of "peak" TD, HSR and MP, for 1, 3 and 5 min epochs, supports and extends upon the findings of previous literature, suggesting there is no change in measures of physical (peak) performance during periods of fixture congestion (Carling & Dupont, 2011; Dupont et al., 2010), when utilizing a comparable number of match observations (i.e. sample sizes). Indeed, Carling and Dupont (2011) found no significant change in whole match, TD (Game 1 = 10,494 ± 514 m, Game 2 = 10,949 ± 853 m, Game 3 = 10,795 ± 618 m) or HSR (Game 1 = 2667 ± 200 m, Game 2 = 2629 ± 398 m, Game 3 = 2414 ± 145 m) when competing in three successive matches within ≤7 days. While current findings may support the research of Carling and Dupont (2011), the use of whole match data is likely to mask the intricacies of the intermittent high-intensity activity that occurs during competitive match-play. As such, while the current results demonstrate that players can maintain their ability to perform intense bouts of physical activity throughout a match (i.e. no change in peak data across 15 min epochs), this should be analysed in combination with the average TD and HSR data (across each 15 min epoch). An approach which is supported by Julian et al.'s (2021) recent systematic review regarding fixture congestion.

In contrast to the "peak" data, current results suggest that analysis of 1, 3 and 5 min average TD values and 3 min average HSR values highlights a significant reduction towards the end of the match (75–90 min split), during periods of fixture congestion. This supports previous research from Carling et al. (2011) and Jones et al. (2019), who both reported reductions in physical activity during periods of fixture congestion. Similar to the present study, Jones et al. (2019) examined the impact of fixture congestion on measures of physical performance by partitioning matches in 15 min splits. Jones et al. (2019) reported reductions in TD during periods of fixture congestion, suggesting that this response was accounted for through the players' ability to "consciously adopt" pacing strategies, which resulted in reduced volumes of lower-intensity distance, with the intention to facilitate and maintain high intensity activity. In addition to the reduced values during the final periods of a match (75–90 min), the current data found greater average TD and HSR values, for both 3 and 5 min epochs during the penultimate 15 min period (60–75 min) of match play. As such, the view that players "consciously" adopt pacing strategies to maintain levels of high-intensity activity may be contested. Rather, a player's ability to maintain any sort of pacing strategy towards the end of a match may be inhibited, when required to complete two competitive matches within a 7-day period, suggesting players are simply more vulnerable to (temporal) fatigue. Further research is needed to examine to what extent any changes in physical activity profiles during periods of fixture congestion are a "conscious" decision.

In support of "altered pacing strategies", Waldron and Highton (2014) provide a detailed overview of the central regulation of movement and the implications upon fatigue and pacing strategies within team sports. Waldron and Highton (2014) identified the role of afferent and efferent signals in signalling and command (respectively) of a player's central motor drive, in relation to perceived homoeostatic disturbance. Although beyond the scope of the current paper, a player's "perception" of the homoeostatic disturbances may be altered during periods of fixture congestion, particularly during the later periods of a competitive match, thus resulting in different pacing strategies. This is supported by laboratory observations of soccer exercise protocols, which demonstrate changes in knee flexor strength and muscular activation during simulated periods of congestion, to maintain the same physical output (Page et al., 2019). However, during self-paced competitive match-play, players may alter their activity profiles (e.g. TD and HSR) to preserve physical capabilities, thus resulting in altered pacing strategies of acute physical performance towards the latter stages of a match, as the current data suggests. As such players, coaches and practitioners should consider their tactical approach to matches during periods of fixture congestion as potential alterations in pacing strategies could have implications for substitutions, squad rotation and the overall tactical approach to competitive matches (Waldron & Highton, 2014).

Previously, Jones et al. (2019) suggested that contrasting results and discrepancies within the literature may be explained by the partitioning of matches (e.g., analysis of data across halves or as a full game vs. analysis across 15 min splits). Given the results obtained within this study and the existing literature, the identification, analysis and interpretation of players' physical performance during periods of fixture congestion, is likely dependent upon the methods, metrics and analytical procedures adopted within the collection and examination of the data. Indeed, the use of "peak" values for each 15 min split of competitive soccer match play would suggest that players can maintain their levels of physical performance, during periods of fixture congestion. Similarly, irrespective of whether peak or average values are used, measures of MP were unchanged during periods of fixture congestion. This is supported by Jones et al. (2019), who also found no change in accelerometer derived metrics between games, during periods of fixture congestion. In contrast, current results show 1, 3 and 5 min average TD values, and 3 min average HSR values may result in a different interpretation of the data and therefore the impact periods of fixture congestion have upon players' physical performance. Consequently, while research demonstrates that MP highlights differences between positions in their physical activity profiles and can also be used to detect changes in physical activity within games (Doncaster et al., 2019); MP may not be a sensitive measure for examining changes in physical performance, during periods of fixture congestion. Further research examining the impact of fixture congestion on a player's ability to perform the required accelerations, decelerations and changes of direction, during competitive match-play, is warranted.

Nevertheless, the varying contexts and complexity involved in the analysis and interpretation of physical performance team sports data, should not be ignored. The fact that contextual factors were not accounted for in the current study, is a limitation. Further appreciation towards the impact match-to-match variance can have on measures of intense bouts of "peak" physical performance, during multiple game microcycles, is needed. Indeed, the quality of the opposing team (Gabbett, 2013), phase of the season (Gregson et al., 2010; Kempton et al., 2015), weather conditions, substitutions, context of the match (win/lose margin) and current form (Black & Gabbett, 2014) have all been shown to influence the physical demands of match-play and, where possible, these contextual variables should be considered when analysing and assessing soccer match-play. Admittedly, however, this often needs to be considered in relation to sample size, as the inclusion of these variables is likely to reduce the sample size, thus making comparisons difficult. Considering sample size, a further limitation of the current study was the limited number of 2 game microcycle match profiles. Despite this, the data set is a representative data set from a competitive U23 season, in which all the available 2 game microcycle profiles were included. In addition to this, imbalances between sample sizes were accommodated within the statistical methods used to analyse the data. Finally, given the difference in the reported activity profiles of substitutes and whole-match players, only players who completed the full match were included within the current study. Future research should look to give further consideration towards the impact substitutions may have on the physical performance of their teammates (i.e. analysis of team totals) and whether the tactical approach to substitutions (i.e. earlier substitutions) changes during periods of fixture congestion. The altered pacing strategies of whole-match (90 min) players reported within the literature, could be a consequence of earlier substitutions, as substitutions have been shown to punctuate the progressive decline in high intensity running observed across a team (Orchard et al., 2012).

Previous research examining the affect periods of fixture congestion has on players' physical performance has tended to utilize match averages (i.e. across 90 min or 15 min splits) when assessing the physical demands of soccer match-play, rather than "peak" periods of activity. Future research should seek to examine the impact periods of fixture congestion has upon "peak" physical performance, specifically in relation to players positions due to the varying demands commonly reported within the literature (Bush et al., 2015; Doncaster et al., 2019; Di Salvo et al., 2007). This was not possible in the current study, due to the reduced number of 2 game microcycle match observations; however, such research will provide practitioners and researchers with position-specific data that is likely to be beneficial for training prescription, recovery strategies, tactics and athlete monitoring. Moreover, elite football teams are increasingly challenged with 3 game microcycles as well as extended periods of fixture congestion across multiple microcycles (e.g., 5 games across 2 weeks), thus adding another dimension to this topic area, which requires further investigation.

Conclusion

Analysis of the players' physical performance during acute periods of physical match-play, either via the identification of peak or average values, provides useful information regarding players' physical performance capabilities. Incidentally, current results suggest that the extent to which periods of fixture congestion impact upon players' physical performance is likely dependent upon the methods, metrics and analytical procedures adopted within the collection and examination of the data. Indeed, while 1, 3 and 5 min peak values for TD, HSR and MP displayed no change during periods of fixture congestion, 1, 3 and 5 min average TD values and 3 min average HSR values displayed significantly different results, during the final period of competitive match-play, when competing in periods of fixture congestion. Furthermore, while beyond the scope of the current study, the potential for altered pacing strategies during periods of fixture congestion, and the associated physiological mechanisms requires further investigation. Nevertheless, given the tendency and increased frequency of fixture congestion within professional soccer, across several leagues and competitions, it is apparent that practitioners and researchers should consider the means by which "physical performance" is being assessed. Indeed, the quantification and examination of "peak" periods could be employed to ensure that players are able to maintain acute bouts of physical performance, during periods of fixture congestion.

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References

Barnes, C., Archer, D. T., Hogg, B., Bush, M., & Bradley, P. (2014). The evolution of physical and technical performance parameters in English premier league. *International Journal of Sports Medicine*, *35*(13) , 1–6. https://doi.org/10.1055/s-0032-1327652

Bauer, A., Young, W., Fahrner, B., & Harvey, J. (2017). GPS variables most related to match performance in an elite Australian football team. *International Journal of Performance Analysis in Sports*, *15*(1), 187–202. https://doi.org/10.1080/24748668.2015.11868786

Beato, M., Devereux, G., & Stiff, A. (2018). Validity and reliability of global positioning system units (STATSports Viper) for measuring distance and peak speed in sports. *Journal of Strength & Conditioning Research*, *32*(10), 2831–2837. https://doi.org/10.1519/JSC.0000000000002778

Black, G., & Gabbett, T. (2014). Match intensity and pacing strategies in rugby league: An examination of whole-game and interchanged players, and winning and losing teams. *Journal of Strength & Conditioning Research*, *28*(6), 1507–1516. https://doi.org/10.1519/JSC.0b013e3182a4a225

Bush, M., Barnes, C., Archer, D., Hogg, B., & Bradley, P. (2015). Evolution of match performance parameters for various playing positions in the English premier league. *Human Movement Science*, *39*, 1–11. https://doi.org/10.1016/j.humov.2014.10.003

Carling, C., & Dupont, G. (2011). Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? *Journal of Sports Sciences*, *29*(1), 63–71. https://doi.org/10.1080/02640414.2010.521945

Carling, C., Le Gall, F., & Dupont, G. (2011). Are physical performance and injury risk in a professional soccer team in match-play affected over a prolonged period of fixture congestion? *International Journal of Sports Medicine*, *33*(1), 36–42 doi:10.1055/s-0031-1283190.

Carling, C., McCall, A., Le Gall, F., & Dupont, G. (2015). The Impact of short periods of fixture congestion on injury risk and patterns in an elite football club. *British Journal of Sports Medicine* *50*(12) , 1–6. https://doi.org/10.1136/bjsports-2015-095501

Coutts, A. J., Kempton, T., Sullivan, C., Bilsborough, J., Cordy, J., & Rampinini, E. (2015). Metabolic power and energetic costs of professional Australian Football match-play. *Journal of Science & Medicine in Sport*, *18*(2), 219–224. https://doi.org/10.1016/j.jsams.2014.02.003

Cunningham, D. J., Shearer, D. A., Carter, N., Drawer, S., Pollard, B., Bennett, M., Eager, R., Cook, C. J., Farrell, J., Russell, M., & Kilduff, L. P. (2018). Assessing worst case scenarios in movement demands derived from global positioning systems during international rugby union matches: Rolling averages versus fixed length epochs. *PLOS ONE*, *13*(4), e0195197. https://doi.org/10.1371/journal.pone.0195197

Dellal, A., Lago-Peñas, C., Rey, E., Chamari, K., & Orhant, E. (2015). The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. *British Journal of Sports Medicine*, *49*(6), 390–394. https://doi.org/10.1136/bjsports-2012-091290

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F. J., Bachi, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine*, *28*(3), 222–227. https://doi.org/10.1055/s-2006-924294

Doncaster, G., Page, R., White, P., Svenson, R., & Twist, C. (2019). Analysis of physical demands during youth soccer match-play: Considerations of sampling method and epoch length. *Research Quarterly for Exercise and Sport*, *91*(2), 326–334. https://doi.org/10.1080/02701367.2019.1669766

Doncaster, G., & Unnithan, V. (2019). Between-game variation of physical soccer performance measures in highly trained youth soccer players. *Journal of Strength & Conditioning Research*, *33*(7), 1912–1920. https://doi.org/10.1519/JSC.0000000000002132

Dupont, G., Nédélec, M., Mccall, A., Mccormack, D., Berthoin, S., & Wisloff, U. (2010). Effect of 2 soccer matches in a week on physical performance and injury rate. *American Journal of Sports Medicine*, *38*(9), 1752–1758. https://doi.org/10.1177/0363546510361236

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (*4th* ed.). Sage.

Gabbett, T. (2013). Influence of the opposing team on the physical demands of elite rugby league match play. *Journal of Strength & Conditioning Research*, *27*(6), 1629–1635. https://doi.org/10.1519/JSC.0b013e318274f30e

Gregson, W., Drust, B., Atkinson, G., & Salvo, V. (2010). Match-to-match variability of high speed activities in premier league soccer. *International Journal of Sports Medicine*, *31*(4), 237–242. https://doi.org/10.1055/s-0030-1247546

Jones, R., Greig, M., Mawene, Y., Barrow, J., & Page, R. (2019). The influence of short-term fixture congestion on position specific match running performance and external loading patterns in English professional soccer. *Journal Sports Sciences*, *37*(12), 1338–1346. https://doi.org/10.1080/02640414.2018.1558563

Julian, R., Page, R., & Harper, L. (2021). The effect of fixture congestion on performance during professional male soccer match-play: A systematic critical review with meta-analysis. *Sports Medicine*, *51*(2), 255–273. https://doi.org/10.1007/s40279-020-01359-9

Kelly, D., Strudwick, A., Atkinson, G., Drust, B., & Gregson, W. (2019). Quantification of training and match-load distribution across a season in elite English premier soccer players. *Science and Medicine in Football 4*(1), 59–67 . https://doi.org/10.1080/24733938.2019.1651934

Kempton, T., Sullivan, C., Bilsborough, J., Cordy, J., & Coutts, A. (2015). Match-to-match variation in physical activity and technical skill measures in professional Australian football. *Journal of Science & Medicine in Sport*, *18*(1), 109–113. https://doi.org/10.1016/j.jsams.2013.12.006

Lacome, M., Simpson, B., Cholley, Y., Lambert, P., & Buchheit, M. (2018). Small-sided games in elite soccer: Does one size fit all? *International Journal of Sports Physiology and Performance*, *13*(5), 568–576. https://doi.org/10.1123/ijspp.2017-0214

Malone, J., Di Michele, R., Morgans, R., Burgess, D., Morton, J., & Drust, B. (2015). Seasonal training-load quantification in elite English premier league soccer players. *International Journal of Sports Physiology and Performance*, *10*(4), 489–497. http://dx.doi.org/10.1123/ijspp.2014-0352

Malone, J., Lovell, R., Varley, M. C., & Coutts, A. (2017). Unpacking the black box: Applications and considerations for using GPS devices in sport. *International Journal of Sports Physiology and Performance*, *12*(s2), S218–S226. https://doi.org/10.1123/ijspp.2016-0236

Orchard, J., Driscoll, T., Seward, H., & Orchard, J. (2012). Relationship between interchange usage and risk of hamstring injuries in the Australian football league. *Journal of Science and Medicine in Sport*, *15*(3), 201–206. https://doi.org/10.1016/j.jsams.2011.11.250

Page, R., Marrin, K., Brogden, C., & Greig, M. (2019). Physical response to a simulated period of soccer-specific fixture congestion. *Journal of Strength & Conditioning Research*, *33*(4), 1075–1085. https://doi.org/10.1519/JSC.0000000000002257

Sparks, M., Coetzee, B., & Gabbett, T. (2017). Variations in high-intensity running and fatigue during semi-professional soccer matches. *International Journal of Performance Analysis in Sport*, *16*(1), 122–132. https://doi.org/10.1080/24748668.2016.11868875

Varley, M., Elias, G., & Aughey, R. (2012). Current match-analysis techniques underestimation of intense periods of high-velocity running. *International Journal of Performance Analysis in Sport*, *7* (2) , 183–185 https://doi.org/10.1123/ijspp.7.2.183 .

Waldron, M., & Highton, J. (2014). Fatigue and pacing in high-intensity intermittent team sport: An update. *Sports Medicine*, *44*(12), 1645–1658. https://doi.org/10.1007/s40279-014-0230-6