Quantification of training load during one, two and three game week schedules in professional soccer players from the English Premier League: implications for carbohydrate periodization

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Running head: Training load and game frequency

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Abstract

Muscle glycogen is the predominant energy source for soccer match play though its importance for soccer training (where lower loads our observed) is not well known. In an attempt to better inform carbohydrate (CHO) guidelines, we therefore quantified training load in English Premier League soccer players (n=12) during a one, two and three game week schedule (weekly training frequency was four, four and two, respectively). In a one game week, training load was progressively reduced (P<0.05) in three days prior to match day (total distance = 5223 ± 406, 3097 ± 149 and 2912 ± 192 m for day 1, 2 and 3, respectively). Whilst daily training load and periodization was similar in the one and two game weeks, total accumulative distance (inclusive of both match and training load) was higher in a two game week (32.5 ± 4.1 km) versus one game week (25.9 ± 2 km). In contrast, daily training total distance was lower in the 3 game week (2422 ± 251 m) versus the one and two game weeks though accumulative weekly distance was highest in this week (35.5 ± 2.4 km) and more time (P<0.05) was spent in speed zones >14.4 km.h^{-1} (14, 18 and 23% in the one, two and three game weeks, respectively). Considering that high CHO availability improves physical match performance but high CHO availability attenuates molecular pathways regulating training adaptation (especially considering the low daily customary loads reported here e.g. 3-5 km per day), we suggest daily CHO intake should be periodized according to weekly training and match schedules.

Key Words: carbohydrate, glycogen, high-intensity, periodization

Introduction

Soccer is an invasive field game characterized by an intermittent activity profile where brief periods of high intensity anaerobic type activity are superimposed on a larger background of exercise that taxes the aerobic energy system (Drust, Cable & Reilly, 2000). The physical demands of soccer match play are well known where players typically cover distances of 10-14 km per match (Dellal *et al.*, 2011; Di Salvo *et al.*, 2007; Bloomfield, Polman & O'Donoghue, 2007; Bangsbo, Mohr & Krustrup, 2006; Fernandes, Caixinha & Malta, 2007). The vast majority of this distance has been previously classified as low to moderate intensity (speeds 0–19.8 km/h) (Bradley *et al.*, 2009), whereas high-intensity running (speeds >19.8 km/h) accounts for ~8% of the total distance completed (Rampinini, Coutts, Castagna, Sassi & Impellizzeri, 2007).

In relation to sources of energy production for match play, muscle glycogen is the predominant substrate, so much so that 50% of muscle fibres have been classified as empty or partially empty at the end of a game (Krustrup *et al.*, 2006). As such, glycogen depletion is commonly cited as a contributing factor for the progressive fatigue (i.e. reduction in high-intensity running) observed towards the end of a game (Bangsbo, 1994; Bangsbo *et al.*, 1991; Mohr *et al.*, 2003; Reilly & Thomas, 1976; Rampinini, Impellizer, Castagna, Coutts & Wisløff, 2009). Accordingly, the nutritional recommendations for optimal match play performance advise high carbohydrate (CHO) availability before, during and after games (Burke, Hawley, Wong & Jeukendrup, 2011; Burke, Loucks & Broad, 2006) so as to promote high muscle glycogen stores (Bangsbo, Graham, Kiens & Saltin, 1992; Balsom, Wood, Olsson, & Ekblom, 1999), maintain plasma glucose levels and ensure the ability to perform technical and cognitive skills (Ali & Williams, 2009; Russell & Kingsley, 2014).

In contrast to match demands, the physical demands of training in elite professional players are not currently well documented and are limited to reports of a single week exposure (Owen *et al.*, 2014), average values over a 10-week period (Gaudino *et al.*, 2013) and most recently, a season long analysis by our group (Malone *et al.*, 2015). The management of training load is traditionally considered in weekly microcycles consisting of one game per week (i.e. Saturday-to-Saturday schedule), though it is noteworthy that elite soccer players often play two (e.g. Sunday-to-Saturday) or three (e.g. Sunday-Wednesday-Saturday) games in a seven-day period. This is largely due to involvement in numerous competitions (i.e. domestic league / cup competitions, European competitions) and periods of intense fixture schedules such as the winter period (Morgans, Orme, Anderson, Drust & Morton, 2014). Such scenarios place considerable demands on sports scientists to monitor and manage training load to ensure optimal match day performance and recovery (Morgans, Adams, Mullen, McLellan & Williams, 2014; Nédélec *et al.*, 2014) whilst also preventing injury (Dellal, Lago-Peñas, Rey, Chamari & Orchant, 2015; Dupont *et al.*, 2010) and symptoms of over-training (Morgans *et al.*, 2014).

Changes in game frequency and the associated training load also has obvious implications for nutritional strategies given that the metabolic demands and typical daily energy expenditure are likely to vary according to the specific weekly training scenario. This is especially important for the role of CHO given that high CHO availability will promote match day physical and technical performance while deliberately *reducing* CHO availability during training may promote training adaptations such as mitochondrial biogenesis (Bartlett, Hawley & Morton, 2015), increase lipid oxidation (Horowitz, Mora-Rodriguez, Byerley & Coyle, 1997) and hence, potentially maintain a desirable body composition (Morton, Robertson, Sutton & MacLaren, 2010; Milsom *et al.*, 2015). Such data therefore suggest that a periodized approach to CHO intake may be beneficial in order to maximize the aforementioned factors. However, before CHO guidelines can be prescribed for elite soccer players, there is a definitive need to better understand the interaction and accumulation of both the training and match load during differing weekly fixture/training schedules.

Accordingly, the aim of the present study was to simultaneously quantify both training and match load during three different weekly game schedules. To this end, we monitored professional outfield players from the English Premier League during a one, two and three game per week schedule completed in the 2013-2014 season.

Methods

Participants

Twelve elite outfield soccer players from an English Premier League team (mean ± SD: age 25 ± 5 years, body mass 81.5 ± 7.5 kg, height 1.80 ± 0.05 m) participated in this study. The participating players consisted of three wide defenders, three central defenders, three central midfielders, one wide midfielder, and two centre forwards (CF). All subjects were familiarized with the training protocols prior to the investigation. This study was conducted according to the requirements of the Declaration of Helsinki and was approved by the University Ethics Committee of Liverpool John Moores University.

Study overview

Training and match data were collected over 3 different 7-day periods during the 2013-2014 English Premier League soccer season. The weeks were taken from the calendar months April, February and December for the one, two and three game weeks, respectively. These weeks were chosen as they included the most participants for the respective weeks throughout the entire season (one game week n = 10, two game week n = 10 and three game week n = 7). Although there are other weeks that represent these scenarios, these 3 different weeks met the essential prerequisites in being the only 3 weeks during the in season where players started all games and completed all training sessions during the chosen week. The one game week had 2 days off and 4 training days before the match. After match 1 in the two game week, there was 1 recovery day and 4 training days before match 2. After match 1 in the two game week, there was 1 recovery day and 1 training day before match 2 and the same schedule in between match 2 and 3. A total number of 10 training sessions (94 individual) and 6 games (51 individual) were observed during this investigation. This study did not influence or alter training sessions in any way. Training and match data collection for this study was carried out at the soccer club's outdoor training pitches and both home and away English Premier League stadiums, respectively. Training data were also analysed in relation to day of the weekly microcycle (i.e. day 1 and day 2) as apposed to the match day minus approach used by Malone *et al.* (2015). This was due to clarity in regards to examining the different weekly scenarios.

Training Data

Each player's physical activity during each training session was monitored using portable global positioning system (GPS) units (Viper pod 2, STATSports, Belfast, UK). This device provides position velocity and distance data at 10 Hz. Each player wore the device inside a custom made vest supplied by the manufacturer across the upper back between the left and right scapula. This position on the player allows the GPS antenna to be exposed for a clear satellite reception. This type of system has previously been shown to provide valid and reliable estimates of instantaneous and constant velocity movements during linear, multidirectional and soccer-specific activities (Coutts & Duffield, 2008; Castellana, Casamichana, Calleja-Gonzalez, Roman & Ostojic, 2011; Varley, Fairweather & Aughey, 2012). All devices were activated 30-minutes before data collection to allow acquisition of satellite signals, and synchronize the GPS clock with the satellite's atomic clock (Maddison & Ni Mhurchu, 2009). Following each training session, GPS data were downloaded using the respective software package (Viper PSA software, STATSports, Belfast, UK) and were clipped to involve the main team session (i.e. the beginning of the warm up to the end of the last organized drill). In order to avoid inter-unit error, players wore the same GPS device for each training sessions (Buchheit *et al.*, 2014a; Jennings, Cormack, Coutts, Boyd & Aughey, 2010).

Match Data

Each player's match data were examined using a computerized semi-automatic video match-analysis image recognition system (Prozone Sports Ltd®, Leeds, UK) and were collected using the same methods as Bradley *et al.* (2009). This system has previously been independently validated to verify the capture process and subsequent accuracy of the data (Di Salvo, Collins, McNeil & Cardinale, 2006; Di Salvo, Gregson, Atkinson, Tordoff & Drust, 2009).

Data analysis

Variables that were selected for analysis included duration, total distance, average speed (total distance divided by training duration) and 6 different speed categories. These speed categories were broken down into the following thresholds: standing (0-0.6 km · h^{-1}), walking (0.7-7.1 km · h^{-1}), jogging (7.2-14.3 km · h^{-1}), running (14.4-19.7 km · h^{-1}), high-speed running (19.8-25.1 km · h^{-1}), and sprinting (>25.1 km · h^{-1}). The speed thresholds for each category are similar to those reported previously in match analysis research (Bradley *et al.*, 2009; Mohr *et al.*, 2003; Rampinini *et al.*, 2007) and are commonly used day to day in professional soccer clubs. . In addition to the absolute distance covered within each speed zone, the distance completed within each zone was also calculated as a percentage of total distance completed so as to create an “intensity distribution profile”.

Statistical Analysis

All the data are presented as the mean ± standard deviation (SD). For descriptive purposes, mean and (when applicable) SD values for each position are reported in the “daily” analyses, although no statistical comparison was made between positions due to a limited number of players in each position. Data were analysed using linear mixed models, with physical load parameters as the dependent variables. Day of the week was used as the fixed factor in the “daily” analyses, while week type was used as the fixed factor in the “accumulated data” analysis.

A random intercept was set for each individual player in both types of analysis. When there was a significant ($p<0.05$) effect of the fixed factor, Tukey post-hoc pairwise comparisons were performed to identify which days or week types differed. Standardised pairwise differences were calculated to determine an effect size (ES) for each significant difference between categories of the fixed factor. The absolute ES value was evaluated according to the following thresholds: < 0.2 = trivial, 0.2-0.6 = small, 0.7-1.2 = moderate, 1.3-2.0 = large, and > 2.0 = very large. The statistical analysis was carried out with R, version 3.0.3.

Results

Day-to-day variations in training load across one, two and three game weeks

As a global index of training and match load, both total distance and average speed during training sessions and games are displayed in Figure 1. Statistical comparisons between days regarding total distance and average speed within each specific weekly scenario are discussed separately below. Duration of activity and distance covered within specific speed zones are also shown in Table 1 and 2, respectively. In addition to the global indices of training and match load (see below text), main effects (all $P<0.01$) across the 7-day period for distance completed within each movement category were also observed within each week (see Table 1 and 2). For issues of brevity, pairwise comparisons between specific days are symbolized within Table 1 and 2. To avoid confusion between weeks and for presentation of data, days will be referred to as day 1, day 2 etc. as opposed to the MD minus format used by Malone *et al.* (2015).

*** TABLE 1 ABOUT HERE ***

*** TABLE 2 ABOUT HERE ***

*** FIGURE 1 ABOUT HERE ***

One Game Week Schedule

There was a significant effect of day ($P<0.01$) for total distance and average speed (see Figure 1A and B). Specifically, in training total distance on day 4 was slightly higher than day 3 (estimated difference: 873 m, ES=0.3) but day 5 and day 6 were both slightly lower than day 3 (-1253 m, ES=0.4 and -1438 m, ES=0.5) and moderately lower than day 4 (-2126 m, ES=0.8 and -2311 m, ES=0.8), respectively ($P<0.01$ for all comparisons). However, day 5 and day 6 displayed no significant difference from each other (-185 m, ES=0.1; $P=0.95$). Average speed on day 4 was slightly higher than day 3 (11.4 $m.min^{-1}$, ES=0.5) but day 5 and day 6 were both moderately lower than day 3 (-17.6 $m.min^{-1}$, ES=0.7 and -27.6 $m.min^{-1}$, ES=1.1) and largely lower than day 4 (-29.0 $m.min^{-1}$, ES=1.2 and -39.0 $m.min^{-1}$, ES=1.6), respectively. Despite no significant differences in total distance between day 5 and 6, average speed was slightly lower on day 6 compared with day 5 (-10 $m.min^{-1}$, ES=0.4) thus reflective of lower training intensity ($P<0.01$ for all comparisons).

Two Game Week Schedule

There was a significant effect ($P<0.01$) of day for total distance and average speed (see Figure 1C and D). Specifically, when compared to day 3, total distance was moderately higher on day 4 (4040 m, ES=1.2), day 5 (2943 m, ES=0.8) and day 6 (1018 m, ES=0.3) (all $P<0.01$). However, compared to day 4 total distance was slightly lower on day 5 (-1097 m, ES=0.3) and moderately lower on day 6 (-3022 m, ES=0.9). Finally, total distance on day 6 was moderately lower than day 5 (-1925 m, ES=0.6). No significant differences were present between distance covered and average speed in games on day 1 and day 7 (247 m, ES=0.1 and 3.7 $m.min^{-1}$, ES=0.1). Average speed, when compared to day 3, was slightly higher on day 4 (8.7 $m.min^{-1}$, ES=0.3) and day 5 (8.2 $m.min^{-1}$, ES=0.3) but moderately lower on day 6 (-20.1 $m.min^{-1}$, ES=0.8) compared to day 3 (all $P<0.01$). Average speed on day 6 was also moderately lower compared to day 4 (-29.7 $m.min^{-1}$, ES=1.1) and day 5 (-29.2 $m.min^{-1}$, ES=1.1) (both $P<0.01$) though no significant differences existed between day 4 and 5 (-0.5 $m.min^{-1}$, ES<0.1). No significant difference was apparent regarding average speed between games on day 1 and day 7 (3.7 $m.min^{-1}$, ES=0.1).

Three Game Week Schedule

No significant difference was observed for total distance (589 m, ES=0.3, $P=0.89$) during training undertaken on days 3 and 6 though average speed was slightly lower on day 6 (-7.2 $m.min^{-1}$, ES=0.2, $P<0.01$). Although total distance did not differ between the 3 games undertaken, average speed was slightly higher in match 2 (day 4) compared with match 1 (day 1) (9.6 $m.min^{-1}$, ES=0.3, $P<0.01$) and also slightly higher than match 3 (day 7) (5.3 $m.min^{-1}$, ES=0.2, P=0.04).

Accumulative Weekly Loads

Weekly accumulative duration of activity, total distance and distance within specific speed zones are displayed in Figure 2 A-F and are inclusive of both training and matches. Figure 3 also displays the distance completed within each zone, as expressed as a percentage of the total distance completed. For all of the aforementioned parameters a significant effect of week was observed (all $P<0.001$). Duration of accumulated activity was largely higher in two game week compared with both the one game week (50 min, ES=1.7, $P<0.001$) and moderately higher compared to the three game week (35 min, ES=1.2, $P<0.01$) though no significant difference was apparent between one game week and three game week (15 min, ES=0.5, P=0.19). The two game week (7684m, ES=1.6, $P<0.01$) and three game week (9349m, ES= 2.0, $P<0.01$) produced largely higher accumulative total distance than the one game week though the three game week and two game week were not significantly different from each other (1665m, ES=0.4, P=0.13). Significant differences ($P<0.01$) in distance in speed zone 0-0.6 $km.h^{-1}$ were present between all week types such that increasing game frequency progressively increased distance, both when expressed in absolute value or as percentage of total distance covered. Walking distance (speed zone 0.7-7.1 $km.h^{-1}$) was largely higher in two game week (2012m, ES=1.3, $P<0.01$) and moderately higher in three game week (1627m, ES=1.0, $P<0.05$) compared with one game week, though no significant differences were apparent between two game week and three game week (385m, ES=0.2, P=0.79). However, when expressed as a percentage of total distance, walking distance showed an opposite tendency, being moderately higher in one game week compared to two game week (6.4%, ES =1.2, P<0.01) and largely higher when compared to three game week (9.6%, ES = 1.8, P<0.01). The difference between two game and three game week was small (3.2%, ES = 0.6, P<0.01). Distance covered during jogging (speed zone 7.2-14.3 km.h^{-1}) displayed a similar pattern to walking such that distance was largely higher in both two game week (3642m, ES=1.6, P<0.01) and three game week (3881m, ES=1.7, P<0.01) compared with one game week, though no significant differences were apparent between two game week and three game week (238m, ES=0.1, P=0.9). In percentage values, there was a small significant difference between two game week and one game week (1.7 %, ES = 0.6, P≤0.05), while the differences between three game week and the one and two game week were not significant (<1.6 %, ES<0.5, both P>0.05).

Given the increase in game frequency, distances covered in running (speed zone 14.4-19.7 km.h^{-1}), high speed running (speed zone 19.8-25.1 km.h^{-1}) and sprinting (speed zone >25.2 km.h^{-1}) all displayed significant differences (P<0.01) between all week types both when expressed as absolute or percentage values. For running distance, two game week (1769m, ES=1.4; 3.0%, ES= 1.2) and three game week (2560m, ES=2.0; 4.6%, ES=1.8) were largely higher than one game week whilst three game week (791m, ES=0.6; 1.6%, ES = 0.6) was also moderately greater than two game week. For high speed running distance, two game week (652m, ES=0.9; 1.1%, ES = 0.6) and three game week (1417m, ES=1.9; 2.9%, ES = 1.6) were, moderately and largely higher, respectively, than the one game week whilst the three game week (764m, ES=1.0; 1.9%, ES = 1.0) was also moderately greater than two game week. Finally, for sprint distance, three game week was, respectively, largely and moderately higher than one game week (659m, ES = 1.7; 1.6%, ES = 1.6), and two game week (413m, ES=1.1; 1.1%, ES =1.1), whilst two game week was also moderately higher than one game week when examining absolute sprint distance (247m, ES = 0.6). However, only a small difference was observed between one and two game week for sprint distance as percentage (0.4%, ES = 0.4).

*** FIGURE 2 ABOUT HERE ***

*** FIGURE 3 ABOUT HERE ***

Discussion

Given that the physical match demands of elite soccer match play are well documented, nutritional strategies that emphasize high CHO availability to promote physical, technical and cognitive performance are based on sound scientific rationale. In contrast, the physical demands of the typical training sessions completed by elite level soccer players are not well defined, thereby making it difficult to prescribe daily CHO guidelines to promote fuelling, recovery and training adaptation. Additionally, the variations in fixture schedules are likely to further complicate the nutritional requirements to simultaneously promote training adaptations, match day performance and recovery. As such, we hereby provide the first report of daily training load and weekly-accumulated load (reflective of both training and match demands) during one, two and three game week schedules. Importantly, we observed marked differences in daily and accumulated loads within and between game schedules, therefore having implications for the nutritional strategies that should be implemented in different microcycles of the season.

One Game Week Schedule

In the one game per week microcycle, we observed clear evidence of training periodization in the days leading into game day. For example, total distance and average speed were greatest on day 4 (5223 ± 406 m; 80.7 ± 6.3 m/min) and displayed progressive daily reductions on day 5 (3097 ± 149 m; 51.7 ± 2.5 m/min) and 6 (2912 ± 192 m; 41.7 ± 2.8 m/min), commensurate with a reduction in gross training load and intensity. Such patterns of training periodization are different from previous observations from our group (also from the same professional club) whereby evidence of periodization was limited to the day preceding game day only (i.e. Day 6), and was largely reflective of a reduction in training duration as opposed to alterations in loading patterns (Malone *et al.*, 2015). Additionally, the load reported by Malone *et al.* (2015) was higher (e.g. daily total distance 6-7 km) than that observed here, likely due to changes in coaches in the different seasons and the sample size of the different positional groups. Similarly, total distance observed here is lower than that reported (average daily values from one week of 6871-11,860 m) in elite players from the Scottish Premier League (Owens *et al.*, 2014) but higher than that observed in players from another English Premier League soccer team, where mean daily values of 3618-4133 m (over a 10-week period) were observed (Gaudino *et al.*, 2013). Such data therefore clearly highlight the role of the managerial structure and coaching staff in influencing daily training loads and in turn, the daily energy and CHO cost of training.

In relation to specific training intensities, we also observed that the majority of distance was completed in the low to moderate speed zones whereas the distance completed in high intensity zones were largely completed in the game itself (see Table 2, Figure 2 and Figure 3). Such patterns of loading are likely a reflection of training time focusing on tactical and technical elements of match play as opposed to physical aspects of training. Additionally, these data also highlight the importance of time engaged in match play *per se* in relation to potentially maintaining the capacity to perform work in these high-intensity zones.

As expected, we also observed that the total weekly accumulated loads were lower in the one game week schedule compared with the two and three game weeks. It is noteworthy that the total weekly load (hence energy cost) reported here is considerably lower (e.g. ~25 km) than endurance sports (Esteve-Lanao, San Juan, Earnest, Foster & Lucia, 2005) where the competitive situation (like soccer) is also CHO dependent (O'Brien, Vigui, Mazzeo & Brooks, 1993). For example, the accumulative weekly distance completed by British middle, long and marathon distance runners were 123, 138 and 107 km, respectively, when tapering for competition (Spilsbury, Fudge, Ingham, Faulkner & Nimmo, 2015). Given such differences in both daily and accumulative weekly load, we therefore suggest that the traditional high dietary CHO guidelines (e.g. 6-10 g/kg body mass) commonly advised to endurance athletes and "team" sport athletes may not always be appropriate for professional soccer players. This is especially pertinent given recent data from our group and others demonstrating that high CHO availability may actually attenuate training-induced adaptations of human skeletal muscle (Bartlett *et al.*, 2015). As such, the potential role of using nutritional manipulations to maximise the training stimulus perhaps becomes even more important in those situations where load is not necessarily high.

When considering the clear evidence of training periodization between days, our data also gives reasoning to the concept of nutritional periodization whereby high CHO availability (e.g. 6-10 g/kg body mass) is promoted on the day prior to match day (Bassau, Fairchild, Rao, Steele & Fournier, 2002), on match day itself (Williams & Serratosa, 2006) and on the day after match day (Burke *et al.*, 2006) thus promoting fuelling and recovery, whereas high CHO availability may not necessarily be required on the other training days. On the basis of the most recent CHO guidelines for training and competition that take into account both intensity and duration (Burke, Hawley, Wong & Jeukendrup, 2011) and in conjunction with the data collected here, we suggest that training days incorporating single sessions are likely to be fuelled accordingly by daily CHO intakes <4-5 g/kg body mass. However, we acknowledge that such suggested intakes may not be applicable for other clubs owing to the fact that different clubs may have different training structures and philosophies and players will also likely be training for different goals (e.g. losing body fat, increasing lean mass etc). Further detailed studies of daily energy expenditure (using measures such as doubly labelled water) and potentially other indicators of total load (e.g. accelerations, decelerations, changes of direction etc) once deemed valid an reliable (Akenhead, French, Thompson & Hayes, 2014), would therefore be required (across teams from within and between different domestic leagues and countries) to more accurately prescribe CHO guidelines for elite level soccer players.

Two Game Week Schedule

Similar to the one game week schedule, we also observed elements of training periodization in the two game week whereby total distance and average speed were greatest on day 4 (5493 ± 421 m; 70.8 ± 5.4 m/min) compared with days 5 (4395 ± 261 m; 70.0 ± 3.8 m/min) and day 6 (2470 ± 184 m; 41.0 ± 2.9 m/min). Given the requirement to recover from the initial game within this week, training load was also lowest on day 3 i.e. 48 hours post-game one (1453 ± 65 m; 63.0 ± 2.0 m/min). Similar to the one game week, typical training intensity during this microcyle was relatively comparable where the majority of time was spent in low-to-moderate intensity zones (see Table 2).

Due to the requirement to compete in two games per week, the total weekly accumulated distance and duration of activity was higher than the one game week schedule and also included significantly more time spent in the high-intensity zones. The duration of activity was also higher in the two game week versus the three game week, likely due to completion of an additional two training sessions where the focus is on recovery from match 1 and also the physical, technical and tactical preparation for match 2. In contrast, such training goals have to be combined into fewer sessions in the three game week where recovery tends to take priority. When taken together, it is likely that the concept of CHO periodization during training days may still be applicable in this 2GW schedule as long as high CHO intake (e.g. 6-10 g/kg body mass) is achieved on the day before match day, during match day and the day after match day.

Three Game Week Schedule

In contrast to the one and two game week schedules, training frequency in the three game week schedule was limited to two sessions. Given the obvious focus of these sessions (i.e. recovery and tactical sessions), markers of training intensity and total distance were similar to that observed in the training sessions occurring on the day preceding match day in both the one and two game week schedules. However, due to competing in three games in the seven day period, the total accumulative distance covered was greater compared with the one game week. Moreover, due to the high intensity nature of matches, time spent in high-intensity speed zones was greater in the three game week compared with both the one and two game week schedule. Given the well documented role of muscle glycogen in fuelling match play (Krustrup *et al.,* 2006) and also the difficulty of replenishing muscle glycogen stores in the 48-72 h post-game period (Krustrup *et al.,* 2011; Gunnarsson *et al.,* 2013), such data therefore clearly highlights the role of high daily CHO availability during this specific microcycle.

This type of weekly scenario is extremely common for those teams who are competing in any European competitions and often compete in midweek games as well as their own league games at the weekends. Games played at this frequency over a short period of time potentially results in residual fatigue and underperformance due to insufficient time for physical recovery whilst also increasing the propensity of injury (Dupont, *et al.,* 2010). However, it is possible that playing games this frequently and undergoing an adequate recovery, players could actually use the game stimulus to maintain or even improve aerobic capacity. If this pattern of loading is prevalent throughout the season, then the need for higher CHO intakes should be increased accordingly.

Study Limitations

Although we provide the first report of training and match load during three different game schedules, our data are not without limitations that are largely a reflection of currently available technology and the practical demands of data collection in an elite football setting. The ecological validity of this study would however be considered high. Firstly, the simultaneous use of both GPS and Prozone® to quantify training and match demands, respectively, has obvious implications for the comparability of data between systems (Harley, Lovell, Barnes, Portas & Weston, 2011; Buchheit *et al.,* 2014b). Nevertheless, this is the approach to monitoring that is commonly employed by sports scientists in the elite soccer environment and is currently a difficult methodological issue to overcome. Secondly, the use of GPS *per se* to make inferences on energy expenditure during training is also limited as methodological issues associated with the technology (e.g. sampling frequency; Aughey, 2011) are likely to underestimate the real energy requirements. Third, we chose to clip the entire training sessions (as opposed to provide drill by drill breakdowns) and this may have led to a lower overall average training intensity. Nevertheless, we initially deemed this valid given that it is the total training time data that are typically used to provide coaches with training reports. Future studies providing drill-by-drill characteristics would now appear warranted.

This study is also reflective of one team only (albeit reflective of a top English Premier League team) and hence may not be representative of the customary training demands of other domestic teams (Gaudino *et al.,* 2013) or from other countries (Owen *et al.,* 2014) that may be influenced by different managerial and coaching philosophies. For example, as players of a lower standard generally undergo higher load during match play (Bradley *et al.*, 2013) there is likely to be a greater total requirement for CHO. Finally, although we selected our chosen weekly scenarios on the basis of the number of players who completed all games and training sessions, it is worth noting that the pattern of loading is likely to be different during different phases of the season due to factors such as residual fatigue. As such, there is a definitive need to more accurately quantify daily energy expenditure (that would also take in account energy expenditure during any resistance training sessions) and energy intake so as to more accurately inform nutritional periodization strategies.

Conclusion

In summary, we quantify for the first time the daily training and accumulative weekly load (reflective of both training and match play) in professional soccer players during a one, two and three game per week schedule. Importantly, we report that customary training loads (e.g. total distance ranging from 3-5 km per day) are likely lower than other athletes in team (e.g. Australian football) and endurance sports, as well as observing evidence of periodization of training load between days within each microcylce (i.e. reduction of total distance and intensity when tapering for match day). When taken together, these data support the concept of CHO periodization whereby CHO is altered in accordance with the daily training load as well as the requirement to fuel and recover from match play. This concept is especially relevant given that muscle glycogen is the predominant energy source for soccer match play but also that consistently high levels of muscle glycogen may attenuate training adaptations. Future studies providing more detailed measures of energy expenditure and additional indicators of training load as well as players' habitual energy intakes are now required to more accurately prescribe CHO guidelines for elite level soccer players.

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FIGURE 1 – Total distance and average speed completed in training sessions and matches duration during the 7-day testing period for different positions and squad average. Figures A and B = one game week, Figures C and D = two game week and Figures E and F = three game week. Bar 1 = Wide Defender, bar 2 = Centre Back, bar 3 = Centre Midfielder, bar 4 = Wide Midfielder, bar 5 = Centre Forward, bar 6 = Squad Average (this sequence of positions is identical in all days and week types). White bars = training days and black bars = match days. [a] denotes difference from day 3, [b] denotes difference from day 4, [c] denotes difference from day 5 and [d] denotes difference from day 6, all $P<0.05$.

FIGURE 2 – Accumulative weekly A) Duration, B) Total distance, C) Standing distance, D) Walking distance, E) Jogging distance, F) Running distance, G) High speed running distance and H) Sprint distance. [a] denotes difference from one game week, [b] denotes difference from two game week, all $P<0.05$.

FIGURE 3 – Intensity distribution expressed as percentage of distance completed within each speed zone. Numbers inset represent actual percentage values. [a] denotes difference from one game week, [b] denotes difference from two game week, all $P<0.05$.

TABLE 1 – Training and match duration during the 7-day testing period for different positions and squad average. WD = Wide Defender, CB = Centre Back, CM = Centre Midfielder, WM = Wide Midfielder, CF = Centre Forward, X =

Day Off and R = Recovery that includes a variety of activities such as cold water immersion, foam rolling, massage and pool related activities but no field based activity. **Bold** indicates data obtained from matches. [a] denotes difference from day 3, [b] denotes difference from day 4, [c] denotes difference from day 5 and [d] denotes difference from day 6, all $P<0.05$.

TABLE 2 –Distances covered at different speed thresholds (representative of squad average data) during training and matched completed in the 7-day testing period. X = Day Off and R = Recovery that includes a variety of activities such as cold water immersion, foam rolling, massage and pool related activities but no field based activity. **Bold** indicates data obtained from matches and HSR = High-speed running. [a] denotes difference from day 3, [b] denotes difference from day 4, [c] denotes difference from day 5, [d] denotes difference from day 6 and [e] denotes difference from day 7, all $P<0.05$.