Quantification of seasonal long physical load in soccer players with different starting status from the English Premier League: implications for maintaining squad physical fitness

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Running head: Starting status and seasonal workload in soccer

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Abstract

Purpose. To quantify the accumulative training and match load during an annual season in English Premier League soccer players classified as starters (n=8, started ≥60% of games), fringe players (n=7, started 30-60% of games) and non-starters (n=4, started <30%% of games). ***Methods.*** Players were monitored during all training sessions and games completed in the 2013-2014 season with load quantified using GPS and Prozone technology, respectively. ***Results.*** When including both training and matches, total duration of activity (10678 ± 916, 9955 ± 947, 10136 ± 847 min; P=0.50) and distance covered (816.2 ± 92.5, 733.8 ± 99.4, 691.2 ± 71.5 km; P=0.16) was not different between starters, fringe and non-starters, respectively. However, starters completed more (all P<0.01) distance running at 14.4-19.8 km/h (91.8 ± 16.3 v 58.0 ± 3.9 km; ES=2.5), high speed running at 19.9-25.1 km/h (35.0 ± 8.2 v 18.6 ± 4.3 km; ES=2.3) and sprinting at >25.2 km/h (11.2 ± 4.2, v 2.9 ± 1.2 km; ES=2.3) than non-starters. Additionally, starters also completed more sprinting (P<0.01. ES=2.0) than fringe players who accumulated 4.5 ± 1.8 km. Such differences in total high-intensity physical work done were reflective of differences in actual game time between playing groups as opposed to differences in high-intensity loading patterns during training sessions. ***Conclusions.*** Unlike total seasonal volume of training (i.e. total distance and duration), seasonal high-intensity loading patterns are dependent on players' match starting status thereby having potential implications for training programme design.

Key Words: GPS, Prozone, high-intensity zones, training load

Introduction

Soccer match play is characterized by brief bouts of high-intensity linear and multidirectional activity interspersed with longer recovery periods of lower intensity.[1] Elite players typically cover 10-14 km in total distance per game.[2-6] where both high intensity (speeds > 14.4 km · h^{-1}) and very high-intensity running distance (speeds > 19.8 km · h^{-1}) contribute ~25 and ~8% of the total distance covered, respectively.[7,8] Top-class soccer players also perform 150-250 intense actions per game[9] and complete a very high-intensity run approximately every 72 s.[8]

In order to successfully meet these demands, the physical preparation of elite players has become an indispensable part of the professional game, with high fitness levels required to cope with the ever-increasing demands of match play.[10,11] Nonetheless, despite nearly four decades of research examining the physical demands of soccer match play,[12] the quantification of the customary training loads completed by elite professional soccer players are not currently well known. For players of the English Premier League, such reports are limited to a 4-week winter fixture schedule,[13] a 10-week period,[14] seasonal long analysis[15] and most recently, an examination of the effects of match frequency in a weekly microcycle. [16] It is noteworthy that the absolute physical loads of total distance (e.g. < 7 km), high intensity distance (e.g. < 600 m) and very high intensity distance (e.g. < 400 m) collectively reported in these studies do not near recreate those completed in matches. As such, although the typical current training practices of professional players may be sufficient in order to promote recovery and readiness for the next game (thus reducing risk of over-training and injury), it could also be suggested that it is the participation in match play itself that is the most appropriate stimulus for preparing players for the physical demands of match play. This point is especially relevant considering previous evidence demonstrating significant positive correlations between individual in season playing time and aspects of physical performance including sprint performance and muscle strength.[17]

Such differences between match and training load can be particularly challenging for fitness and conditioning staff given that players in a first team squad are likely to receive different loading patterns, depending on whether they regularly start matches or not. In this way, discrepancies in physical loads between players could lead to differences in important components of soccer-specific fitness which may subsequently present itself on match day when players not accustomed to match loads are now required to complete the habitual physical loads performed by regular starting players. The challenge of maintaining squad physical fitness is also technically difficult, given both organisational and traditional training practices inherent to professional soccer. For example, in the English Premier League, it is not permitted for players to train on the same pitch where the game was played for >15 minutes post-match. Furthermore, it is often common practice for the entire playing squad to be given 1-2 days of recovery following each game (consisting of complete inactivity or light recovery activities only), especially in those instances where the fixture schedule consists of the traditional Saturday-to-Saturday schedule. [16]

With this in mind, the aim of the present study was to quantify the accumulative training and match load (hence total accumulative physical load) across an annual season in those players considered as regular starters, fringe players and non-starters. To this end, we monitored outfield players from the English Premier League (who competed in the 2013-2014 season) who were classified as starters (starting ≥60% of games), fringe players (starting 30-60% of games) and non-starters (starting <30% of games). We specifically hypothesised that both fringe and non-starting players would complete significantly less total physical load (especially in high-intensity zones) than starting players, thereby providing practical applications for the development of soccer-specific conditioning programme designed to maintain squad physical fitness.

Methods

Subjects

Nineteen professional outfield soccer players from an English Premier League team (mean ± SD: age 25 ± 4 years, body mass 79.5 ± 7.8 kg, height 180.4 ± 6.4 cm) took part in the study. When quantifying data from the entire "in-season analysis" there were 8 starters (mean ± SD: age 25 ±5 years, body mass 80.6 ± 8.3 kg, height 178.8 ± 6.3 cm), 7 fringe (mean ± SD: age 26 ± 4 years, body mass 79.7 ± 7.4 kg, height 181.0 ± 7.3 cm) and 4 non-starters (mean ± SD: age 23 ± 3 years, body mass 74.5 kg, height 181.5 ± 6.9 cm). Players with different position on the field were tested: 5 wide defenders, 4 central defenders, 6 central midfielders, 2 wide midfielders and 3 attackers. Long-term injuries were excluded from this study if they were absent for on field training for duration >4 weeks. The 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.

Design

Training and match data were collected over a 39-week period during the 2013-2014 competitive season from August 2013 until May 2014. The team used for data collection competed in 3 official domestic competitions across the season. For the purposes of this current study, training sessions included for analysis consisted of all of the 'on pitch' training each player was scheduled to undertake. Sessions that were included in the analysis were team training sessions, individual training sessions, recovery sessions and rehabilitation training sessions. A total number of 181 team-training sessions (2182 individual), 159 rehab sessions (213 individual), 28 recovery sessions (179 individual), 43 competitive matches including substitute appearances (531 individual) and 12 non-competitive games including substitute appearances (33 individual) were observed during this investigation. All data reported are for outdoor field based sessions only. We can confirm that in the season of analysis, the players studied did not do any additional aerobic / high-intensity conditioning in the gym or an indoor facility. However, all players did complete 1-3 optional gym based sessions per week (typically consisting of 20-30 minute long sessions comprising upper and/or lower body strength based exercises). When expressed as 'total time' engaged in training activities (i.e. also inclusive of gym training) and games, the data presented in the present paper therefore represent 78±10, 79±6 and 86±7% of 'total time' for starters, fringe players and non-starters, respectively. This study did not influence or alter any session or game in any way nor did it influence the inclusion of players in training sessions and/or games. Training and match data collection for this study was carried out at the soccer club's outdoor training pitches and both home and away grounds in the English Football League, respectively.

The season was analyzed both as a whole and in 5 different in-season periods consisting of 4x8 weeks (periods 1-4) and 1x7 week period (period 5). Players were split into 3 groups for the entire in season analysis and individually for each in season period. The 3 groups consisted of "starters", "fringe" and "non-starters" and were split based on the percentage of games started for the entire in season (n=8, 7 and 4, respectively) and during the individual period 1 (n=8, 5 and 6, respectively), period 2 (n=9, 5 and 5, respectively), period 3 (n=6, 8 and 5, respectively), period 4 (n=8, 5 and 6, respectively) and period 5 (n=11, 2 and 6, respectively). Starting players started ≥60% competitive games, fringe players started 30-60% of games and non-starting players started <30% of games. The first day of data collection period began in the week commencing (Monday) of the first Premier League game (Saturday) and the last period ended after the final Premier League game. Data for the entire in season and each individual period was further divided into training and matches. As outlined previously, training consisted of all 'on pitch' training sessions that were organised and planned by the clubs coaches and staff and match data consisted of both competitive and non-competitive games. No data from training or games from when players were on International camps were collected.

Methodology

Players' physical activity during each training, rehabilitation, recovery sessions and non-competitive game 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 across the upper back between the left and right scapula inside a custom made vest supplied by the manufacturer. 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 some of the movements related to soccer, although it should be noted that fast, more instantaneous, and more multidirectional movements are measured less accurately.[18-21] 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.[22] 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" organised session i.e. the beginning of the warm up to the end of the last organized drill for each player, the initiation of exercise to the cessation of exercise on individual training, recovery and rehab sessions or the start of the game until the end of the game with any distances and times covered and undergone during the half-time period removed. In order to avoid inter-unit error, players wore the same GPS device for each training sessions.[23,24]

Players' 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.[8] This system has previously been independently validated to verify the capture process and subsequent accuracy of the data.[25]

Variables that were selected for analysis included duration, total distance and 3 different speed categories that were divided into the following thresholds: 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}). High-intensity running consists of running, high-speed running and sprinting (running speed >14.4 km · h^{-1}). Very high-intensity running consists of high-speed running and sprinting (running speed > 19.8 km · h^{-1}). The speed thresholds for each category are similar to those reported previously in match analysis research[7,8] and are commonly used day to day in professional soccer clubs.

Statistical Analysis

All of the data are presented as mean ± standard deviation (SD). Data were analysed using between-group one-way ANOVAs for independent samples. When the F-test was significant ($p<0.05$), post-hoc pairwise comparisons were performed, in which the significance level was adjusted to 0.017 (Bonferroni correction). Cohen's d indices were calculated for all pairwise differences to determine an effect size (ES). 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.

Results

Seasonal long comparison of "total" physical load

A comparison of seasonal physical load (inclusive of both training and matches) is presented in Table 1. Although there was no significant difference in total duration (P=0.502) and distance covered (P=0.164) between player categories, non-starters completed significantly less running (P=0.002; ES=2.5), high-speed running (P=0.004; ES=2.3) and sprinting (P=0.003; ES=2.3) than starters. Additionally, fringe players completed significantly less sprinting than starters (P=0.002; ES=2.0) though no differences were apparent in running (P=0.062) and high-speed running (P=0.038) between these groups.

Seasonal long comparison of total "training" and "match" physical load

A comparison of seasonal long training and match load is presented in Figure 1A and B (for duration and total distance). In relation to matches, both fringe and non-starters completed less duration of activity (both P<0.01; ES=2.7 and 5.7, respectively) and total distance (both P<0.01; ES=5.4 and 2.5, respectively) compared with starters. Additionally, non-starters also completed less duration (P=0.001; ES=0.7) and total distance than fringe players (P=0.001; ES=0.7). In relation to training, differences were only apparent between non-starters and starters where non-starters spent longer time training (P=0.003; ES=2.4) and covered greater total distance (P=0.003; ES=2.3).

Seasonal long comparison of "training" and "match" physical load in high-intensity speed zones

Seasonal long distance covered in running, high-speed running and sprinting in both training and matches is displayed in Figure 2A-C. In relation to matches, both fringe and non-starters completed significantly less distance in running (both P<0.01; ES=1.7 and 4.0, respectively), high-speed running (both P<0.01; ES=2.0 and 3.4, respectively) and sprinting (both P<0.01; ES=2.2 and 2.6, respectively) compared with starters. In addition, fringe players covered significantly more distance in running than non-starters (P=0.008; ES=0.7). However, no differences were apparent between fringe and non-starters for high-speed running and sprinting (P=0.026 and 0.045; ES=0.7 and 0.5, respectively). In contrast to match load, no differences were observed between groups for distance completed in running, high-speed running and sprinting during training (P=0.297, 0.658 and 0.802, respectively).

Comparison of "total" physical load within specific in-season periods

Total duration, total distance and distance completed in high-intensity speed zones within 5 in-season periods of the season are presented in Table 2. For duration of total activity, significant differences were only observed in periods 4 (P=0.004; ES=1.9) and 5 (P=0.001; ES=2.2) where non-starters completed less total duration of activity than starters, respectively. Similarly, non-starters also completed less total distance than starters in periods 3-5 (all P<0.01, respectively; ES=1.9, 3.1 and 3.4, respectively), less running in periods 1, 3, 4 and 5 (all P<0.01, respectively; ES=1.0, 2.3, 3.6 and 3.6, respectively), less high-speed running in periods 3-5 (all P<0.01, respectively; ES=2.1, 2.6 and 3.0, respectively) and less sprinting in periods 2-5 (all P<0.01, respectively; ES=1.6, 2.5, 3.0 and 2.5, respectively). Furthermore, starters completed more sprinting distance than fringe in periods 3 and 4 (both P<0.01, respectively; ES=2.2 and 1.6, respectively) but fringe only differed from non-starters in period 4 only where they completed more sprinting (P=0.006; ES=1.2).

Comparison of "training" and "match" physical load within specific in-season periods

Duration of activity, total distance, running, high-speed running and sprinting in matches are displayed in Figure 3A-E. As expected, in periods 1-5, starters had higher duration and than both non-starters (all P<0.01; ES=2.7, 2.6, 13.2, 11.9 and 5.6, respectively) and fringe (all P<0.01; ES=1.9, 1.6, 4.0, 5.5 and 2.5, respectively) whilst fringe players also exhibited higher durations than non-starters in periods 3-5 (all P<0.01; ES=0.9, 1.3 and 2.3). Similarly, starters covered higher total distances in periods 1-5 than both non-starters (all P<0.01; ES=2.6, 2.5, 9.5, 12.8 and 5.9, respectively) and fringe (all P<0.01; ES=1.9, 1.6, 3.0, 5.1 and 2.4, respectively) and fringe players covered higher total distances than non-starters in periods 3-5 (all P<0.01; ES=0.9, 1.3 and 2.3, respectively).

In relation to specific speed zones, starters completed more running in periods 1-5 than non-starters (all P<0.01; ES=2.2, 2.1, 5.1, 7.2 and 4.7, respectively), more high-speed running in periods 1-5 (all P<0.01; ES=1.8, 1.9, 3.5, 5.5and 3.8) and more sprinting in periods 2-5 (all P<0.01; ES=1.7, 2.8, 3.2 and 2.5). Moreover, starters completed more running than fringe players in periods 3 (P=0.009; ES=1.7) and 4 (P=0.001; ES=2.6), more high-speed running in periods 3 (P=0.003; ES=2.0) and 4 (P=0.004; ES=2.1) and more sprinting in periods 3 (P=0.001; ES=2.2) and 4 (P=0.012; ES=1.7). Fringe players also covered more running distance in periods 3-5 (all P<0.01; ES=0.9, 1.3 and 2.3, respectively), more high-speed running in periods 4 (P=0.002; ES=1.3) and 5 (P=0.008; ES=2.2) and more sprinting in period 4 (P=0.003; ES=1.3) than non-starters.

Duration of activity, total distance, running, high-speed running and sprinting in training are displayed in Figure 4A-E. In contrast to matches, total duration of activity was only different in period 3 (P=0.014; ES=1.8) where non-starters trained for longer durations than starters. In addition, starters completed less total distance in periods 3 and 4 compared to non-starters (both P<0.01; ES=2.5, 1.8, respectively) and non-starters also covered more total distance in period 3 than fringe players (P=0.007; ES=0.4). Non-starters also covered more running than starters and fringe players in period 3 (both P<0.01; ES=2.1 and 0.6, respectively) and more high-speed running than starters in period 4 (P=0.015; ES=1.5). Finally, no differences were apparent between groups for sprinting during periods 1-5 (P=0.506, 0.361, 0.605, 0.521 and 0.487).

Discussion

The aim of the present study was to quantify the accumulative training and match load (and total accumulative physical load) during an annual season in those players considered as regular starters, fringe players and non-starters. Contrary to our hypothesis, we observed that starting status had no effect on the apparent total volume completed, as reflected by total duration of activity and total distance covered during the season. Perhaps more important, however, was the observation of significant differences in the pattern of activity completed within specific high-intensity speed zones. In this regard, we report that starters generally completed more distance in running, high-speed running and sprinting zones than both fringe and non-starting players. This effect was largely due to differences in game time between groups as opposed to differences in training loading patterns. Given the role of training intensity in promoting soccer-specific fitness,[10, 26-28] our data therefore suggest that the training practices of those players not deemed to be receiving appropriate game time should be altered to include more emphasis on recreating the high-intensity demands of match play, so as to potentially maintain overall squad fitness, game readiness and reduce injury risk.

To the authors' knowledge, this is the first study to report seasonal long physical loads completed by elite professional soccer players. In our seasonal long accumulation analysis, we observed no evidence of starting status affecting total duration of activity or total distance covered across the entire in-season period (see Table 1). For example, total duration and total distance were similar in starters, fringe and non-starters. These distances are substantially higher (e.g. approximately 400 km) than that observed in a competitive in-season in other team sports such as Australian Football[29] likely due to shorter seasons in the latter i.e. 22 weeks (18 weeks in the study) versus 39 weeks in the English Premier League.

Although we observed no differences in the seasonal long profile between groups (i.e. duration and total distance covered), the proportion of this volume made up from training and game is, as expected, significantly different between groups. For example, in relation to training, starters displayed lower duration and total distances than non-starters but not fringe players. This fact is, of course, due to the fact that starting players engage in "recovery" training activities and days after games as opposed to traditional training sessions.[13,16] When quantifying match load, however, starters displayed higher duration and total distance than both fringe players and non-starters. Given the obvious difference between the physical and physiological demands between training and matches,[13,16] such data could potentially suggest that the long-term physiological adaptations arising within these playing groups are likely very different. This point is especially apparent when considering the large discrepancy between intensity specific physical loads between groups. For example, starters covered higher distances in running and high-speed running speed zones, respectively, when compared with non-starters, but not fringe players (see Table 1). In addition, seasonal long distance covered whilst sprinting was also higher in starters compared to both fringe players and non-starters. As such, these data demonstrate that although players are able to maintain similar volume across the in-season period, distance covered in high-intensity zones is considerably greater in starters.

The differences in high-intensity loading patterns between groups is also especially relevant when considering that such differences were not due to alterations in training loads but rather, merely due to starters engaging in the high-intensity activity associated with match play. Indeed, we observed no difference in running, high-speed running and sprinting in training *per se* between starters, fringe players and non-starters. In contrast, starters displayed higher distance in matches when running, high-speed running and sprinting compared to fringe and non-starters (see Figure 2A-C). Such data clearly highlight that it is the participation in match play per se which represents the most appropriate opportunity to achieve high-intensity loading patterns. The practical implications of such discrepancies are important for designing training programmes to maintain overall squad physical fitness and game readiness. Indeed, the distances covered at these speeds during games display strong associations to physical capacity[30,31] and thus, players not consistently exposed to such stimuli during the season may eventually display de-training effects when compared to that displayed in the pre-season period.[10,17] Indeed, completion of high-intensity activity (even at the expense of total physical load done) is both sufficient and necessary to activate the molecular pathways that regulate skeletal muscle adaptations related to both aerobic[32,33] and anaerobic[34] performance. Additionally, when those players classified as fringe or non-starters are then required to start games, a potential for injury also exists due to the necessity to complete uncustomary loading patterns.[35]

In addition to the seasonal long physical loads, we also quantified the training and match load within 5 discrete periods of the in-season period. In this analysis, we observed that variations in physical load between groups were especially evident in periods 3, 4 and 5, an effect that was especially apparent between starters and both non-starters and fringe players for total duration, total distance and total zone 6 activity (i.e. sprinting). Similar to the seasonal long analysis, these differences between groups were also largely reflective of differences in game time as opposed to training time. Such differences in loading within specific in-season periods are likely due to tactical and technical differences associated with specific fixture schedules. For example, in the present study, period 3 was the winter fixture schedule[13] whereas periods 4 and 5 were reflective of a period where the team under investigation were challenging for domestic honours. In all of these periods, the management and coaching staff displayed little squad rotation policies and hence, differences in loading inevitably ensued.

Despite the novelty and practical application of the current study, our data are not without limitations, largely a reflection of currently available technology and the practical demands of data collection in an elite football setting. Firstly, the simultaneous use of both GPS and Prozone® to quantify training and competitive match demands, respectively, has obvious implications for the comparability of data between systems.[38,39] Nevertheless, during the chosen season of study, it was against FIFA rules to wear GPS in competitive matches. Whilst it is now within the rules to wear GPS in competitive games, it is still not common policy due to managers' preferences, players' comfort issues and poor signal strength due to the roofing in many stadiums in the English Premier League. Secondly, we also chose to not report data from games or training from International camps given that the loads of these practices were not controlled by the current research team or club's tactical and coaching staff. Finally, this study is only reflective of one team (albeit reflective of a top English Premier League team) and hence may not be representative of the customary training and match demands of other domestic teams or teams from other countries. When taken together, the simultaneous use of GPS in training and games, quantification of load in additional settings and the use of wider based samples all represent fruitful areas for future research.

Practical Applications

Given that we observed distinct differences in high-intensity distance completed throughout the season, our data have obvious practical implications for training programme design. In this regard, data suggest that players classified as fringe and non-starters should engage in additional high-intensity training practices and/or complete relevant time in non-competitive friendlies and U21 games in an attempt to recreate the high-intensity physical load typically observed in competitive first team games. This point is especially important given the relevance and importance of high-intensity activity in both building and maintaining aspects of soccer specific fitness.[10,36,37] Furthermore, our observation of more marked differences in periods 3, 4 and 5 of the season also suggest that specific attention should be given to those periods of the season when tactical choices dictate low-squad rotation policies. Future studies should now correlate changes in physical load during the season to seasonal variation in soccer-specific fitness components as well as introducing soccer-specific training interventions at the relevant in-season periods (e.g. Iaia et al. [37]).

Conclusions

In summary, we quantify for the first time the accumulative training and match load (and total accumulative physical load) during an annual season in those players considered as regular starters, fringe players and non-starters. Importantly, although we report that total duration of activity and total distance covered was not different between playing groups, we observed that starters generally completed more time in high-intensity zones than fringe and non-starters players. Our data demonstrate the obvious importance of participation in game time for completing such high-intensity physical load. Such data suggest that the training practices of these latter groups should potentially be manipulated in order to induce comparable seasonal workloads.

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TABLE 1 – Total duration (minutes), total distance (km), running distance (km), high-speed running distance (km) and sprinting distance (km) covered across the entire in-season period, as inclusive of both training and matches. * denotes difference from starters, $P<0.05$ (Bonferroni corrected).

TABLE 2 – Total duration (minutes), total distance (km), running distance (km), high-speed running distance (km) and sprinting distance (km) within 5 specific in-season periods. * denotes difference to starters, # denotes difference to fringe players, $P<0.05$ (Bonferroni corrected).

FIGURE 1 – Accumulative season long A) duration and B) total distance in both training and matches. Shaded bars = training and open bars = matches. * denotes difference to starters (matches), # denotes difference to fringe players (matches), a denotes difference to starters (training), $P<0.05$ (Bonferroni corrected).

FIGURE 2 – Accumulative season long A) running distance, B) high-speed running distance and C) sprinting distance in both training and matches. Shaded bars = training and open bars = matches. * denotes difference to starters, $P<0.05$ (Bonferroni corrected).

FIGURE 3 – Within period accumulative A) duration, B) total distance, C) running distance, D) high-speed running distance

and E) sprinting distance in match per se. * denotes difference to starters, $^{\#}$ denotes difference to fringe players, $P<0.05$ (Bonferroni corrected).

FIGURE 4 – Within period accumulative A) duration, B) total distance, C) running distance, D) high-speed running distance and E) sprinting distance in training per se. * denotes difference to starters, $^{\#}$ denotes difference to fringe players, $P<0.05$ (Bonferroni corrected).