Daily distribution of macronutrient intakes of professional soccer players from the English Premier League

Journal:	*International Journal of Sport Nutrition & Exercise Metabolism*
Manuscript ID	IJSNEM.2016-0265.R2
Manuscript Type:	Original Research
Keywords:	glycogen, protein, carbohydrate, soccer

Daily distribution of macronutrient intakes of professional soccer players from the English Premier League

Liam Anderson[1], Robert J Naughton[2], Graeme L Close[1], Rocco Di Michele[3], Ryland Morgans[4], Barry Drust[1] and James P Morton[1]

[1]Research Institute for Sport and Exercise Sciences
Liverpool John Moores University
Tom Reilly Building
Byrom St Campus
Liverpool
L3 3AF
UK

[2]School of Human and Health Sciences
Harold Wilson Building
University of Huddersfield
Queensgate
Huddersfield
HD1 3DH
UK

[3]Department of Biomedical and Neuromotor Sciences
University of Bologna
Bologna
Italy

[4]Cardiff City Football Club
Leckwith Road
Cardiff
CF11 8AZ
UK

Running head: Distribution of macronutrient intake

Address for correspondence:
Dr James Morton
Research Institute for Sport and Exercise Sciences
Liverpool John Moores University
Tom Reilly Building
Byrom St Campus
Liverpool
L3 3AF
United Kingdom
Email: J.P.Morton@ljmu.ac.uk
Tel: +44 151 904 6233

Abstract

The daily distribution of macronutrient intake can modulate aspects of training adaptations, performance and recovery. We therefore assessed the daily distribution of macronutrient intake (as assessed using food diaries supported by the remote food photographic method and 24 h recalls) of professional soccer players (n=6) of the English Premier League during a 7-day period consisting of two match days and five training days. On match days, average carbohydrate (CHO) content of the pre-match (<1.5 g.kg^{-1} body mass) and post-match (1 g.kg^{-1} body mass) meals (in recovery from an evening kick-off) were similar (P>0.05) though such intakes were lower than contemporary guidelines considered optimal for pre-match CHO intake and post-match recovery. On training days, we observed a skewed and hierarchical approach (P<0.05 for all comparisons) to protein feeding such that dinner (0.8 g.kg^{-1})>lunch (0.6 g.kg^{-1})>breakfast (0.3 g.kg^{-1})>evening snacks (0.1 g.kg^{-1}). We conclude players may benefit from consuming greater amounts of CHO in both the pre-match and post-match meals so as to increase CHO availability and maximize rates of muscle glycogen re-synthesis, respectively. Furthermore, attention should also be given to ensuring even daily distribution of protein intake so as to potentially promote components of training adaptation.

Keywords: glycogen, protein, carbohydrate, soccer,

Introduction

The elite professional soccer player will typically compete in two games per week as well as partake in three to five daily training sessions (Malone et al., 2014; Morgans et al., 2015; Anderson et al., 2015). As such, the fundamental goal of the sport nutritionist is to ensure sufficient energy intake in order to promote match day physical performance and recovery (Burke et al., 2011). In relation to professional players of the English Premier League (EPL), we recently observed (in a companion paper) self reported mean daily carbohydrate (CHO) intakes of 4.2 and 6.4 $g.kg^{-1}$ body mass on training days and match days, respectively (Anderson et al., 2017). On this basis, we therefore suggested that elite players potentially under-consume CHO when compared with those guidelines that are considered optimal to promote muscle glycogen storage (Burke et al., 2011).

Nonetheless, in order to provide more informative dietary guidelines (as opposed to total daily energy intake *per se*), there is also the definitive need to quantify the daily "distribution" of energy and macronutrient intakes. Such a rationale is well documented for CHO given the relevance of both timing and absolute CHO intake in relation to promoting pre-match loading and post-match muscle glycogen re-synthesis (Ivy et al., 1988a; Ivy et al., 1988b). To the authors' knowledge, however, the daily distribution of CHO intake on both training and match days in elite level soccer players has not been reported.

In contrast to our previous observations of CHO periodization between training and match days (Anderson et al., 2017), we observed consistent daily protein intakes (e.g. 200 g), the magnitude of which was higher than previously reported in the literature (Maughan, 1997; Bettonviel et al., 2016; Gillen et al., 2016). Similar to daily CHO intakes, however, there is also a requirement to quantify daily distribution of protein intakes (Areta et al., 2013; Mamerow et al., 2014). Indeed, these latter authors demonstrated that the timing and even distribution of daily protein doses may have a more influential role in modulating muscle protein synthesis when compared with the absolute dose of protein intake *per se*, an effect that is evident in response to both feeding alone (Mamerow et al., 2014) and post-exercise feeding (Areta et al., 2013). Such skewed approaches to protein feeding have been previously observed in elite youth UK soccer players (Naughton et al., 2016), adult soccer players of the Dutch league (Bettonviel et al., 2016) and a mixed sex cohort of multisport Dutch athletes (Gillen et al. 2016). However, given that we observed higher absolute daily protein intakes (Anderson et al., 2017) compared with all of the aforementioned studies, there is also a need to further understand the habitual protein feeding patterns in adult professional UK soccer players.

Accordingly, the aim of the present study was to therefore quantify the daily distribution of energy and macronutrient intakes of professional soccer players of the EPL. Importantly, we provide distribution data related to both training and match days with practical applications therefore related to promoting training adaptations and match day performance. For analysis of total daily energy intake, daily energy expenditure and training and match load of this cohort, the reader is directed to a previous companion paper (Anderson et al., 2017).

Methods

Participants

Six male professional soccer players from an EPL first team squad (mean ± SD; age 27 ± 3 years, body mass 80.5 ± 8.7 kg, height 180 ± 7 cm, body fat 11.9 ± 1.2 %, fat mass 9.2 ± 1.6 kg, lean mass 65.0 ± 6.7 kg) volunteered to take part in the study. Players with different positions on the field took part in the study and included 1 wide defender, 1 central defender, 2 central midfielders (1 defending and 1 attacking), 1 wide midfielder and 1 center forward. All six players who took part in the study have represented their respective countries at national level. All players remained injury free for the duration of the study. The study was conducted according to the Declaration of Helsinki and was approved by the University Ethics Committee of Liverpool John Moores University.

Study Design

Data collection was conducted during the EPL 2015-2016 in-season in the month of November. Players continued with their normal in-season training that was prescribed by the club's coaching staff and were available to perform in two competitive games on days 2 and 5 during data collection. During data collection, game 1 kicked off at 20:05 hours and game 2 kicked off at 16:15 hours, both being home fixtures in European and domestic league competitions, respectively. Before the study commenced all players underwent a whole body fan beam Duel-energy X-ray absorptiometry (DXA) measurement scan (Hologic QDR Series, Discovery A, Bedford, MA, USA) in order to obtain body composition, in accordance with the procedures described by Nana et al. (2015).

Dietary Intake

Self reported EI was assessed from 7-day food diaries for all players and reported in kilocalories (kcal) and kilocalories per kilogram of lean body mass (kcal/kg LBM). Macronutrient intakes were also analysed and reported in grams (g) and grams per kilogram of body mass (g.kg^{-1}). The period of 7 days is considered to provide reasonably accurate estimations of habitual energy and nutrient consumptions whilst reducing variability in coding error (Braakhuis et al., 2003). On the day prior to data collection, food diaries were explained to players by the lead researcher and an initial dietary habits questionnaire (24 h food recall) was also performed. These questionnaires were used to establish habitual eating patterns and subsequently allow follow up analysis of food diaries. Additionally, they helped to retrieve any potential information that players' may have missed on their food diary input. In addition, EI was also cross referenced from the remote food photographic method (RFPM) in order to have a better understanding of portion size and/ or retrieve any information that players' may have missed on their food diary input. This type of method has been shown to accurately measure the EI of free-living individuals (Martin et al., 2009). To further enhance reliability, and ensure that players missed no food or drink consumption, food diaries and RFPM were reviewed and cross checked using a 24-hour recall by the lead researcher after one day of entries (Thompson & Subar, 2008). As such, the lead researcher used these three sources of energy (i.e. food diaries, 24 h recall and RFPM) intake data in combination to collectively estimate daily energy and macronutrient intake / distribution. To obtain energy and macronutrient composition, the Nutritics professional diet analysis software (Nutritics Ltd, Ireland) was used. Energy and macronutrient intake was further assessed in relation to timing of ingestion. Meals on training days were split into breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. Time and type of consumption was used to distinguish between meals; breakfast (main meal consumed between 6-9.30am), morning snack (foods consumed between the breakfast main meal and the lunch), lunch (main meal consumed between 11.30-1.30pm), afternoon snack (foods consumed between lunch and dinner), dinner (main meal consumed between 5-8pm), and evening snack (foods consumed after dinner and prior to sleep).

Meals on match days were split into pre-match meal (PMM), pre-match snack (PMS), during match (DM), post-match (PM) and post-match recovery meal (PMRM). Timing of events was used to distinguish between meals on match days; PMM (main meal consumed 3 hours prior to kick off), PMS (foods consumed between the PMM and entering the changing rooms after the cessation of the warm up), DM (foods consumed from when the players entered the changing rooms after the warm up until the final whistle or since they were substituted), PM (foods consumed in the changing rooms after the match), PMRM (main meal consumed <3 hours after the end of the match).

Inter-Researcher Reliability of the Methods

To assess inter-researcher reliability, author one, author two and an independent researcher (not included on the authorship) individually assessed energy intake data for one day of one player selected at random. No significant difference was observed (as determined by one-way ANOVA) between researchers for energy (P=0.95), CHO (P=0.99), protein (P=0.95) or fat (P=0.80) intake. Daily totals for researchers 1, 2 and 3 were as follows: energy intake = 3174, 3044 and 3013 kcals; CHO = 347, 353 and 332 g; protein = 208, 201, and 194 g and fat = 106, 92 and 101 g, respectively.

Statistical Analysis

All data are presented as the mean ± standard deviation (SD). Meal distribution data was using linear mixed models with meal as the fixed factor. A random intercept was set for each individual player. When there was a significant ($P < 0.05$) effect of the fixed factor, Tukey post-hoc pairwise comparisons were performed to identify which categories of the factor differed. This whole analysis was performed separately for training and match days. In the match day's analysis, a fixed factor for day was also included to compare energy intake and distribution of the two different match days. In all the analyses, statistical significance was set at P<0.05. The statistical analysis was carried out with R, version 3.3.1.

Results

Energy and Macronutrient Distribution Across Meals on Training Days

There were significant differences in the reported absolute and relative energy and macronutrient between meals consumed on training days ($P<0.01$ for all examined absolute and relative energy intake variables; see Figure 1). Specifically, players consumed higher absolute and relative EI at dinner compared with breakfast, morning, afternoon and evening snacks ($P<0.01$ for all comparisons). Additionally, absolute and relative EI was also greater at lunch compared with the morning and evening snacks ($P<0.01$). Absolute and relative CHO intakes were higher at dinner compared with morning snack (both $P<0.01$), lunch (both $P<0.05$) and evening snack (both $P<0.01$), with relative CHO intake also being higher at dinner compared with breakfast ($P=0.04$).

Protein and relative protein intakes were greater at dinner compared with breakfast, morning snacks, afternoon snacks and evening snacks ($P<0.01$ for all comparisons). In addition, absolute and relative protein intakes were greater at lunch compared with breakfast, morning snacks and evening snacks ($P<0.01$ for all comparisons). Both absolute and relative protein intakes were also higher at breakfast compared with evening snack (both $P<0.02$) and higher at the afternoon snack compared with the evening snack (both $P<0.01$).

In relation to fat intake, both absolute and relative intakes were higher at dinner compared with the morning, afternoon snacks and evening snacks ($P<0.05$ for all comparisons). Additionally, fat intake was also higher at lunch compared with the morning snack ($P<0.01$ for both absolute and relative intakes).

Energy and Macronutrient Intake Across Meals on Match Days

There was no significant difference ($P>0.05$ for all meals; see Figure 2) in absolute and relative energy and macronutrient intake between meals on the two difference match days. However, significant differences were observed between meals consumed on match days for all energy and macronutrient variables (all $P<0.05$; see Figure 2). The absolute and relative energy and protein intake were higher in the PMM and PM compared with the PMS, DM and PMRM (all $P<0.05$). Additionally, the absolute and relative CHO intake were also higher in the PMM and PM compared with the PMS and DM (all $P<0.05$). Fat intake in the PMM and the PM, when expressed in both absolute and relative terms, were higher than the PMS and DM (all P<0.05), where the PMM was also lower than the PMRM (both P<0.05).

Discussion

Having previously quantified the daily "total" energy intake and expenditure of the players studied here (Anderson et al., 2017), the aim of the present study was to subsequently quantify the daily distribution of energy and macronutrient intakes on both training and match days. Importantly, we observed that players adopt a skewed approach to feeding on training days such that absolute energy intake, CHO and protein intake are consumed in a hierarchical manner of dinner>lunch>breakfast>snacks. Moreover, we also observed that players tend to under-consume CHO on match days in relation to pre-match and post-match meals, especially in recovery from an evening kick-off time. Taken together, our data highlight the importance of obtaining dietary data related to distribution (as opposed to total daily energy intake per se, Anderson et al., 2017) given the implications related to components of training adaptation, performance and recovery.

In our companion paper (Anderson et al., 2017), we reported that the players studied herein practiced elements of CHO periodization such that total daily CHO intake was greater on match days (i.e. 6.4 $g.kg^{-1}$ BM) compared with training days (i.e. 4.2 $g.kg^{-1}$ BM). Although such CHO periodization strategies may be in accordance with the principle of "fuel for the work required" (Impey et al. 2016; Bartlett et al., 2015; Hawley & Morton, 2015), we suggested that players were likely under-consuming CHO in terms of maximizing match day physical performance and recovery. Further evidence highlighting this potential "sub-optimal CHO intake" is also provided by the dietary distribution data provided here. For example, in relation to match day itself, our data suggest that players did not meet current CHO guidelines for which to optimize aspects of physical (Burke et al., 2011), technical (Ali & Williams, 2009) and cognitive (Welsh et al., 2002) performance. Indeed, both the pre-match meal (< 1.5 $g.kg^{-1}$ body mass) and CHO feeding during match play (~30 $g.h^{-1}$; four players consumed <30 $g.h^{-1}$, see Anderson et al. 2017) could be considered sub-optimal in relation to those studies (Wee et al., 2005; Foskett et al., 2008) demonstrating higher CHO intakes (e.g. 2-3 $g.kg^{-1}$ body mass and 60 $g.h^{-1}$, respectively) induce physiological benefits that are facilitative of improved high-intensity intermittent performance e.g. high pre-exercise glycogen stores, maintenance of plasma glucose/CHO oxidation during exercise and muscle glycogen sparing.

Given that the present study was conducted during a two game per week schedule, there was the obvious nutritional requirement to maximize muscle glycogen storage in the 24-48 h after each game (Krustrup et al., 2006; Bassau et al., 2002). To this end, we also observed CHO intakes that would be considered sub-optimal in relation to maximizing rates of post-match muscle glycogen re-synthesis (Jentjens & Jeukendrup, 2003). Indeed, in contrast to the well-accepted guidelines of 1.2 $g.kg^{-1}$ body mass for several hours post-exercise, we observed reported intakes of <1 $g.kg^{-1}$ in the immediate period after match day 1 (i.e. the night-time kick off). Such post-game intakes coupled with the relatively low absolute daily intake (i.e. 4 $g.kg^{-1}$) on the subsequent day (see Anderson et al., 2017) would inevitably ensue that absolute muscle glycogen re-synthesis was likely compromised, an effect that may be especially prevalent in type II fibres (Gunnarsson et al., 2013). It is noteworthy, however, that the high absolute protein intakes consumed in the post-match period (i.e. >50 g) would likely potentiate rates of muscle glycogen re-synthesis when consumed in the presence of sub-optimal CHO availability (Van Loon et al., 2000).

Despite our observation of CHO periodization during the weekly microcycle, we previously observed (Anderson et al., 2017) consistent daily protein intakes (approximately 200 g per day), the magnitude of which was higher than that typically reported (<150 g/day) previously for adult (Maughan, 1997; Bettonviel et al., 2016) and youth professional male soccer players (Naughton et al., 2016). Similar to CHO intake, however, it is also prudent to consider the daily distribution of protein feeding given that both that skewed and sub-optimal intakes at specific meal times can reduce rates of muscle protein synthesis (Areta et al., 2013; Mamerow et al., 2014). Indeed, recent data suggest that the timing and even distribution of daily protein doses may have a more influential role in modulating muscle protein synthesis when compared with the absolute dose of protein intake, an effect that is evident in response to both feeding alone (Mamerow et al., 2014) and post-exercise feeding (Areta et al., 2013). In this regard, we observed a skewed pattern of daily protein intake in that absolute protein was consumed in a hierarchical order where dinner>lunch>breakfast>snacks. This finding also agrees with our previous observations on the protein feeding patterns of elite youth soccer players (Naughton et al., 2016) as well as adult players from the Dutch league (Bettonviel et al., 2016) and a mixed sex cohort of Dutch athletes (Gillen et al. 2016). Nonetheless, given that we observed higher daily protein intakes (>200 g/day) compared with the previous studies (typically <150 g/day), examination of daily distribution data also allows us to comment on those meals that led to greater absolute protein intake. In this regard, it appears that an additional absolute intake of approximately 20-25 g at both lunch and dinner accounted for the greater absolute total daily intake.

Based on recent data suggesting that trained athletes (especially those with higher lean mass) may require protein doses of approximately 40 g (MacNaughton et al., 2016) as well as the importance of protein feeding prior to sleep (Res et al., 2012), our data suggest that breakfast and morning, afternoon and bedtime snacks are key times to improve for the present sample. We acknowledge, however, that protein requirements (both in absolute dosing and timing) should be tailored to the specific population in question in accordance with timing of training sessions, training load and moreover, individualized training goals.

Despite the novelty and practical application of the current study, our data are not without limitations, largely a reflection of the practical demands of data collection in an elite football setting. Firstly, this study is reflective of only six players from one team only (albeit reflective of a top EPL team) and hence may not be representative of the customary training and nutritional habits of other teams. Nonetheless, we deliberately recruited players with different playing positions in an attempt to provide a more representative sample of professional soccer players. Secondly, our deliberate choice to study a two game week scenario (as is highly relevant for elite level players) may not be applicable to players of lower standards. Thirdly, as with all dietary analysis studies, our data may be limited by both under-reporting and inter-researcher variability in ability to assess dietary intakes. Indeed, whilst we observed no significant group mean changes in body mass over the data collection period, two of our subjects did appear to under report whereas four of the subjects reported energy intake data that was comparable (within 200 kcal) to energy expenditure data (see Anderson et al. 2017). Finally, both of the games studied here represented home games and hence the nutritional choices are likely to be influenced by the philosophy and service provision of the club coaching and catering staff.

In summary, we simultaneously quantified for the first time the daily distribution of energy and macronutrient intakes of EPL soccer players on both training and match days. Our data suggest that players may benefit from consuming greater amounts of CHO in both the pre-match and post-match meals so as to increase CHO availability and maximize rates of muscle glycogen re-synthesis, respectively. Furthermore, we also observed that daily protein intake was consumed in a hierarchical manner such that dinner > lunch > breakfast > snacks. Attention should also be given to therefore ensuring even distribution of daily protein intake so as to potentially promote components of training adaptation.

Acknowledgements

The authors would like to thank all of the participating players for the cooperation and commitments during all data collection procedures. We would also like to thank the team's coaches for cooperation during data collection.

References

Ali, A., & Williams, C. (2009). Carbohydrate ingestion and soccer skill performance during prolonged intermittent exercise. *J Sports Sci, 27,* 1499-1508.

Anderson, L., Orme, P., Di Michele, R., Close, G.L., Morgans, R., Drust, B., & Morton, J.P. (2015). 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. *J Sports Sci, 4,* 1-10.

Anderson, L., Orme, P., Naughton, R.J., Close, G.L., Milsom, J., Rydings, D., O'Boyle, A., Di Michele, R., Louis, J., Morgans, R., Drust, B., & Morton, J.P. (2017). Energy intake and expenditure of professional soccer players of the English Premier League: evidence of carbohydrate periodization. *Int J Sport Nutr Exerc Metab, In Press.*

Areta, J.L., Burke, L.M., Ross, M.L., Camera, D.M., West, D.W., Broad, E.M., Coffey, V.G. (2013). Timing and distribution of protein ingestion during prolonged recovery from resistance exercise alters myofibrillar protein synthesis. *J Physiol, 591,* 2319-2331.

Bartlett, J.D., Hawley, J.A., & Morton, J.P. (2015). Carbohydrate availability and exercise training adaptation: Too much of a good thing? *Eur J Sport Sci, 15,* 3-12.

Bassau, V.A., Fairchild, T.J., Rao, A., Steele, P., & Fournier, PA. (2002). Carbohydrate loading in human muscle: an improved 1 day protocol. *Eur J Appl Physiol, 87,* 290-295.

Bettonviel, A.EO., Brinkmans, N.Y.J., Russcher, K., Wardenaar, F.C., & Witard, O.C. (2016). Nutritional status and daytime pattern of protein intake on match, post-match, rest and training days in senior professional and youth elite soccer players. *Int J Sport Nutr Exerc Metab, epub ahead of print.*

Braakhuis, A.J., Meredith, K., Cox, G.R., Hopkins, W.G., & Burke, L.M. (2003). Variability in estimation of self-reported dietary intake data from elite athletes resulting from coding by different sports dietitians. *Int J Sport Nutr Exerc Metab, 13,* 152-165.

Burke, L.M., Hawley, J.A., Wong, S.H., & Jeukendrup, A.E. (2011). Carbohydrates for training and competition. *J Sports Sci, 29,* 17-27.

Foskett, A., Williams, C., Boobis, L., & Tsintzas, K. (2008). Carbohydrate availability and energy metabolism during intermittent running. *Med Sci Sports Exerc, 40,* 96-103.

Gillen, J.B., Trommelen, J., Wardenaar, F.C., Brinkmans, N.Y.J., Versteegen, J.J., Jonvik, K.L., Kapp, C., de Vries, J., van den Borne, J.J.G.C., Gibala, M., & van Loon, L.J.C. (2016). Dietary protein intake and distribution patterns of well-trained Dutch athletes. *Int J Sport Nutr Exerc Metab, epub ahead of print.*

Gunnarsson, T.P., Bendiksen, M., Bischoff, R., Christensen, P.M., Lesivig, B., Madsen, K., … Bangsbo, J. (2013). Effect of whey protein- and carbohydrate-enriched diet on glycogen resynthesis during the first 48 h after a soccer game. *Scand J Med Sci Sports, 23,* 508-515.

Hawley, J.A., & Morton, J.P. (2014). Ramping up the signal: promoting enurance training adaptation in skeletal muscle by nutritional manipulation. *Clin Exp Pharmacol Physiol, 41, 608-613.*

Impey, S.G., Hammon, K.M., Shepherd, S.O., Sharples, A.P., Stewart, C., Limb, M., Smith, K., Philp, A., Jeromson, S., Hamilton, D.L., Close, G.L., & Morton, J.P. (2016). Fuel for the work required: a practical approach to amalgamating train-low paradigms for endurance athletes. *Physiol Rep, 4,* e12803.

Ivy, J, L., Katz, A.L., Cutler, C.L., Sherman, W.M., & Coyle, E.F. (1988a). Muscle glycogen synthesis after exercise: effect of time of carbohydrate ingestion. *J Appl Physiol, 64,* 1480-1485.

Ivy, J.L., Lee, M.C., Brozinick, J.T. Jr., Reed. M.J. (1988b). Muscle glycogen storage after different amounts of carbohydrate ingestion. *J Appl Physiol, 65,* 2018-2023.

Jentjens, R., & Jeukendrup, A. (2003). Determinants of post-exercise glycogen synthesis during short-term recovery. *Sports Med, 33,* 117-144.

Krustrup, P., Mohr, M., Steensberg, A., Bencke, J., Kjer, M., & Bangsbo, J. (2006). Muscle and blood metabolites during a soccer game: Implications for sprint performance. *Med Sci Sports Exerc, 38,* 1165-1174.

Malone, J.J., Di Michele, R., Morgans, R., Burgess, D., Morton, J.P., & Drust, B. (2015). Seasonal training-load quantification in elite English premier league soccer players. *Int J Sports Physiol Perform, 10,* 489-497.

Martin, C.K., Han, H., Coulon, S.M., Allen, H.R., Champagne, C.M., & Anton, S.D. (2009). A novel method to remotely measure food intake of free-living people in real-time: The remote food photography method (RFPM). *B J Nutr, 101,* 446-456.

Maughan, R.J. (1997). Energy and macronutrient intakes of professional football (soccer) players. *Br J Sports Med, 31,* 45-47.

Macnaughton, L.S., Wardle, S.L., Witard, O.C., McGlory, C., Hamilton, D.L., Jeromson, S., Lawrence, C.E., Wallis, G.A., & Tipton, K.D. (2016). The response of muscle protein synthesis following whole-body resistance exercise is greater following 40 g than 20 g of ingested whey protein. *Physiol Rep, 4,* e12893.

Mamerow, M.M., Mettler, J.A., English, K.L., Casperson, S.L., Arentson-Lantz, E., Sheffield-Moore, M., Layman, D.K., & Paddon-Jones, D. (2014). Dietary protein distribution positively influences 24-h muscle protein synthesis in healthy adults. *J Nutri, 144,* 876-880.

Morgans, R., Orme, P., Anderson, L., Drust, B., & Morton, J.P. (2014). An intensitve Winter fixture schedule induces a transient fall in salivary IgA in English premier league soccer players. *Res Sports Med, 22,* 346-354.

Nana, A., Slater, G.J., Stewart, A.D., & Burke, L.M. (2015). Methodology review: using dual-energy X-ray absorptiometry (DXA) for the assessment of body composition in athletes and active people. *Int J Sport Nutr Exerc Metab, 25,* 198-215.

Naughton, R.J., Drust, B., O'Boyle, A., Morgans, R., Abayomi, J., Davies, L.G., Morton, J.P., & Mahon, E. (2016). Daily distribution of carbohydrate, protein and fat intake in elite youth academy soccer players over a 7-day training period. *Int J Sport Nutri Exerc Metab, epub ahead of print.*

Res, P.T., Groen, B., Pennings, B., Beelen, M., Wallis, G.A., Gijsen, A.P., Senden, J.M., Van Loon, L.J. (2012). Protein ingestion before sleep improves postexercise overnight recovery. *Med Sci Sports Exerc, 44,* 1560-1569.

Thompson, F., & Subar, A. (2008). Dietary assessment methodology. In A. M. Coulston & C.J. Boushey (Eds.), *Nutrition in the prevention and treatment of disease* (pp. 3-39). San Diego, CA: Academic Press.

Wee, S., Williams, C., Tsintzas, K., & Boobis, L. (2005). Ingestion of a high-glycemic index meal increases muscle glycogen storage at rest but augments its utilization during subsequent exercise. *J App Physiol, 99,* 707-714.

Welsh, R.S., Davis, J.M., Burke, J.R., & Williams, H.G. (2002). Carbohydrates and physical/mental performance during intermittent exercise to fatigue. *Med Sci Sports Exerc, 34,* 723-73.

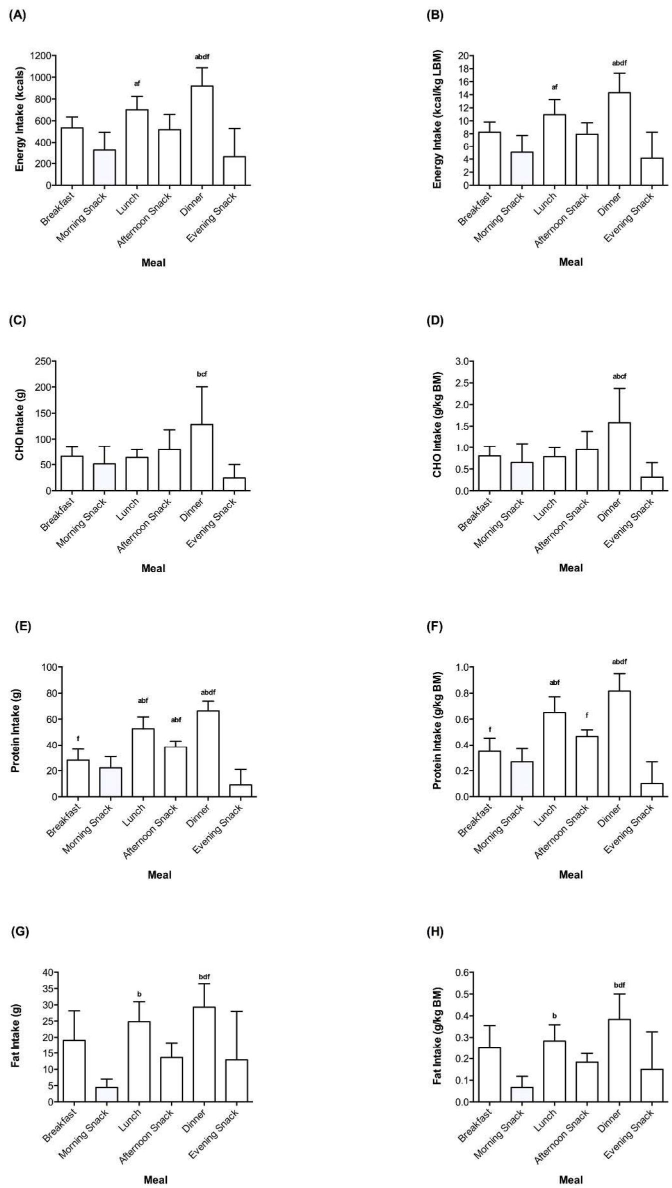

Figure 1. Energy and macronutrient intakes meal distribution on training days. Figure A=absolute energy expenditure, Figure B=energy expenditure relative to lean body mass, Figure C=absolute carbohydrate, Figure D=relative carbohydrate, Figure E=absolute protein, Figure F=relative protein, Figure G=absolute fat and Figure H=relative fat. White bars=training days and black bars=match days. a denotes difference from breakfast, b denotes difference from morning snack, c denotes difference from lunch, d denotes difference from afternoon snack, e denotes difference from dinner, f denotes difference from evening snack.

244x432mm (300 x 300 DPI)

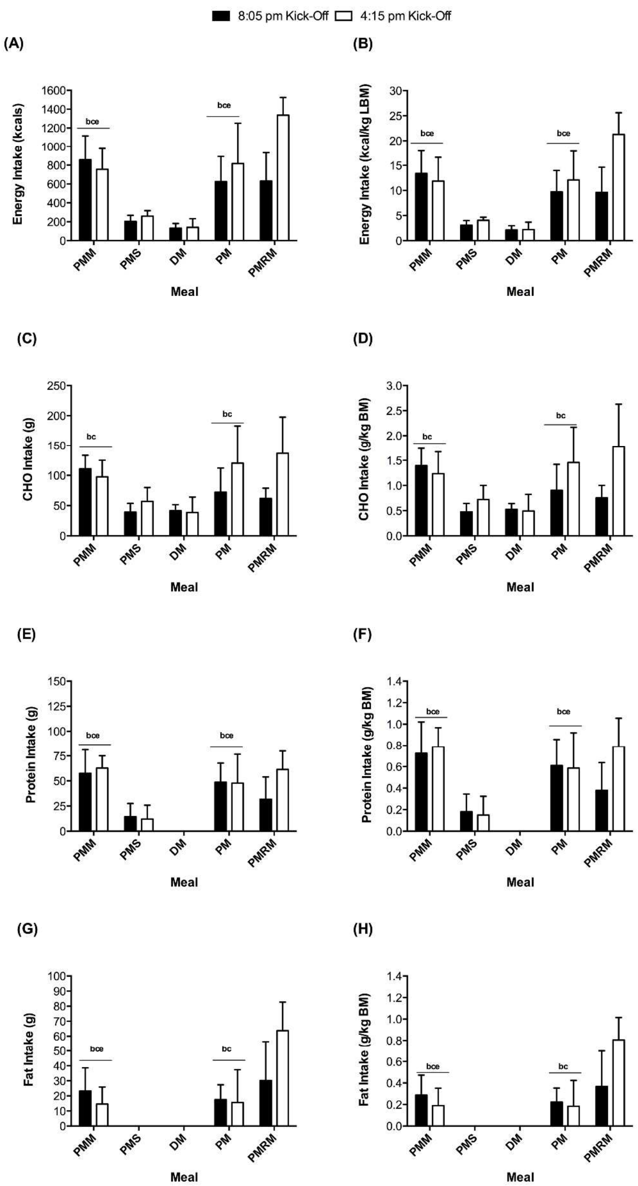

Figure 2. Energy and macronutrient intake meal distribution on the two match days during the study period. Black bars=match day 1 and white bars=match day 2. a denotes difference from PMM, b denotes difference from PMS, c denotes difference from DM, d denotes difference from PM, e denotes difference from PMRM. PMM=Pre Match Meal, PMS=Pre-Match Snack, DM=During-Match, PM=Post-Match, PMRM=Post-Match Recovery Meal.

252x466mm (300 x 300 DPI)