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Article Title: Nutritional Status and Daytime Pattern of Protein Intake on Match, Post-Match, Rest and Training Days in Senior Professional and Youth Elite Soccer Players

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Nutritional status and daytime pattern of protein intake on match, post-match, rest and training days in senior professional and youth elite soccer players

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Abstract

The nutritional status of elite soccer players across match, post-match, training and rest days has not been defined. Recent evidence suggests the pattern of dietary protein intake impacts the daytime turnover of muscle proteins and, as such, influences muscle recovery. We assessed the nutritional status and daytime pattern of protein intake in senior professional and elite youth soccer players and compared findings against published recommendations. Fourteen senior professional (SP) and fifteen youth elite (YP) soccer players from the Dutch premier division completed nutritional assessments using a 24-h web-based recall method. Recall days consisted of a match, post-match, rest and training day. Daily energy intake over the 4-day period was similar between SP (2988±583 kcal/day) and YP (2938±465 kcal/day; p=0.800). Carbohydrate intake over the combined 4-day period was lower in SP (4.7±0.7 g·kg^{-1} BM·day^{-1}) *vs.* YP (6.0±1.5 g·kg^{-1} BM·day^{-1}, p=0.006) and SP failed to meet recommended carbohydrate intakes on match and training days. Conversely, recommended protein intakes were met for SP (1.9±0.3 g·kg^{-1} BM·day^{-1}) and YP (1.7±0.4 g·kg^{-1} BM·day^{-1}), with no differences between groups (p=0.286). Accordingly, both groups met or exceeded recommended daily protein intakes on individual match, post-match, rest and training days. A similar 'balanced' daytime pattern of protein intake was observed in SP and YP. To conclude, SP increased protein intake on match and training days to a greater extent than YP, however at the expense of carbohydrate intake. The daytime distribution of protein intake for YP and SP aligned with current recommendations of a balanced protein meal pattern.

***Keywords**:* dietary assessment, protein metabolism, recovery

Introduction

The physiological demands of soccer training and match play include intermittent bouts of low-intensity exercise, interspersed with dynamic high-intensity efforts (Nédélec et al., 2012). Multiple eccentric muscle contractions are required to perform such dynamic movements that are potentially damaging to skeletal muscle architecture (Nédélec et al., 2012). Training and match play recovery encompasses several factors, including repair and remodelling of skeletal muscle (or skeletal muscle protein remodelling (SMPR)), rehydration, glycogen repletion and immune-protection. Complete recovery following match play can take 48-72 h (Nédélec et al., 2012; Silva et al., 2013). The provision of sufficient dietary carbohydrate (CHO) and protein intake are established components of recovery, particularly for stimulating muscle glycogen resynthesis and SMPR, respectively (Shephard, 1999). Hence, nutritional strategies are essential for elite soccer players to facilitate recovery from training and match play.

Current CHO recommendations for soccer players, like all athletes, are primarily determined by daily exercise duration and intensity (Burke et al., 2011). Daily fluctuations in training load and energy requirements dictate the need to adapt dietary CHO intake on a day-to-day basis (Rollo, 2014). During preseason, when high-intensity training (~1-3 h/day) is typically performed daily, recommended CHO intakes range from 6-10 g·kg body mass (BM)·day^{-1} (Burke et al., 2011). During low- (recovery or skill-based) or moderate-intensity (~1 h) training, recommended CHO intakes range from 3-5 and 5-7 g·kg BM·day^{-1}, respectively (Burke et al., 2011; Burke et al., 2006). To our knowledge, CHO recommendations specific to soccer match play have not been published. However, since muscle glycogen status is firmly established as a primary determinant of fatigue (Bergström et al., 1967) and reduced athletic performance (Hargreaves, 1999), strategies to restore muscle glycogen levels after training or match play are accepted to be an important component of exercise recovery in soccer players (Russell & Kingsley, 2014).

The guidelines informing recommended protein intakes for athletes range from 1.3-1.8 $g \cdot kg^{-1}$ $BM \cdot day^{-1}$ (Phillips & Van Loon, 2011). This recommendation is based on the dietary protein intake, conventionally expressed on a daily basis, necessary to promote SMPR. One component of SMPR is hypertrophy, that predetermines increased strength and power (Tipton & Wolfe, 2004). Thus, protein intake provides a nutritional focus for power/strength-based athletes (Tipton & Witard, 2007). An adequate dietary protein intake during soccer match play is considered necessary to facilitate SMPR after multiple 'damaging' eccentric muscle contractions (Shephard, 1999). In addition, recent work has investigated the optimal protein meal pattern to maximise the daytime response of whole-body protein metabolism (Moore et al., 2012) and muscle protein synthesis (MPS) (Areta et al., 2013; Mamerow et al., 2014) in young individuals. Results indicate that a balanced, compared with an unbalanced, distribution meal pattern of protein intake elicits superior SMPR (Areta et al., 2013; Mamerow et al., 2014). Hence, although often overlooked, both the total daily intake and the distribution meal pattern of dietary protein are important considerations when informing daily protein recommendations for elite soccer players.

Dietary fat recommendations for athletes are expressed as a percentage of total energy intake, with an acceptable macronutrient distribution range of 20-35% of total energy intake (Rodriguez et al., 2009). Lipids are functional components of cell membranes and also assist the absorption of fat-soluble vitamins (Rodriguez et al., 2009). In contrast to CHO and protein, whereby timing of intake in relation to exercise is thought to influence performance and recovery (Burke et al., 2011; Phillips & Van Loon, 2011), the exact role of fat intake for soccer players is not well defined.

Nutritional assessments of soccer players have primarily been conducted in elite youth players (Caccialanza et al., 2007; Garrido et al., 2007; Rico-Sanz et al., 1998; Russell & Pennock, 2011), with few studies in senior professional players (Erp-Baart et al., 1989; Maughan, 1997). To date, only a single study has directly compared the nutritional intake of youth and senior soccer players, reporting that total daily energy and CHO intakes failed to meet published recommendations (Ruiz et al., 2005). Interestingly, energy and CHO intake was lower for senior compared with youth players. However, this study recruited sub-elite, rather than elite soccer players (Ruiz et al., 2005) and failed to report the exercise demands of players on the days that assessments of nutritional status were conducted. Hence, it was not possible to evaluate the influence of activity level (*e.g.*, match or training day *vs.* recovery or rest day) on self-adjusted dietary intakes. To our knowledge, to date no descriptive study has comprehensively characterized the nutritional status of, and comparison between senior professional and youth elite soccer players across match, post-match, training and rest days. Moreover, whilst previous descriptive studies in soccer players have assessed daily protein intakes, no study has explicitly evaluated the daytime protein meal pattern of elite soccer players.

Therefore, the overall aim of this descriptive study was to comprehensively evaluate the nutritional status of senior professional and youth elite soccer players. Total energy and macronutrient intake were analysed on a single match, post-match, rest and training day. In addition, the daytime protein meal pattern of elite soccer players was characterised. Two study hypotheses are presented; first, based on previous results in youth or sub-elite senior soccer players (Caccialanza et al., 2007; Garrido et al., 2007; Ruiz et al., 2005; Russell & Pennock, 2011), we hypothesised that the dietary CHO intake of senior and youth players would fail to meet recommended guidelines. Second, given that the senior professional players undertaking the present study were receiving a higher level of sport science support and sports nutrition education, we hypothesised that senior players would meet protein recommendations.

Methods

Participants

Thirty elite male soccer players from the highest professional division of soccer in The Netherlands participated in this study. Participants were divided into two groups: senior professional players (SP) and youth elite players (YP). Players were from a range of playing positions, with the exception of goalkeepers. All players were involved in regular training and competition over the study duration and were fully informed of study procedures before giving their written informed consent to participate. The School of Sport Research Ethics Committee of the University of Stirling approved the study.

Dietary recall

Participants completed four non-consecutive 24-h dietary recalls. Data were collected from mid-September to the end of October. Players were instructed to maintain their habitual diet throughout the study. Selected days for diet recalls consisted of a match-day, post-match day, rest day and training day. Training days with the highest planned intensity and/or volume sessions were selected as the recall day. A minimum of 3 days separated individual dietary recalls. To reduce the likelihood of behavioural changes in habitual diet, players were randomly selected to provide dietary recalls and did not receive advanced warning regarding which order recalls would take place. On the morning of the selected dietary recall day, players were notified by text message to complete a recall. Two trained nutritionists performed all recalls. All recalls took place at the club on match-, training and recovery days. On rest days, when players did not report to the club, recalls were conducted by telephone.

Dietary recalls were recorded using Compl-eat™ (Wageningen University). This program is based on the five-step multiple-pass method which is a validated technique to increase accuracy of dietary recalls in the general (Bingham et al., 1995; Conway et al., 2004; Conway et al., 2003) and athletic population (Grandjean, 1989; Holway & Spriet, 2011). This 24-h dietary recalls differs from the written food records (Caccialanza et al, 2007; Erdmann et al., 2013; Erp-Baart et al., 1989; Maughan, 1997; Rico-Sanz et al., 1998; Ruiz et al., 2005 and Russell et al., 2011) or the weighed food method (Garrido et al., 2007) used in previous studies within the same population. Daily questionnaires of training load and dietary supplement/sports nutrition product use were collected with the vitality portal (HAN University of Applied Sciences). Interviewers followed the web-based procedure of Compl-eat™ to ensure all recalls were conducted in a similar manner.

Data presentation and statistical analysis

Dietary recalls were analysed for exercise duration, energy and macronutrient intakes over the collective 4-day study period and on separate days. Protein intake also was assessed on a meal-by-meal basis. Seven meal occasions were defined as: before breakfast, breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. The datasets for general macronutrient intake are expressed in absolute (g) and relative ($g \cdot kg^{-1}$ $BM \cdot day^{-1}$) terms, as well as a % of total energy intake (TEI). Protein intake also is expressed on a meal-by-meal basis as g/meal. All supplements consumed during the study period were included in data analysis.

Software package SPSS version 22 was used for all statistical analysis. An independent samples Students t-test was used to assess differences between groups in non time-dependent variables. A two-way repeated-measures ANOVA with time (days or meals) as the within-subject factor and group (SP vs. YP) as the between-subject factor was used to assess differences between groups over time. In case of a significant time effect, post hoc pairwise comparisons with Bonferroni correction were applied to locate differences between days or meals. In case of a significant time × group interaction, post hoc comparisons with Bonferroni correction were applied to locate the time-point that group differences were observed. For all statistical analyses, significance level was set at $p<0.05$. Data are presented as means ± SD.

Results

Player demographics

One player withdrew from the study due to injury. Therefore, a total of 29 soccer players were included in the final analysis. Player demographics of the final sample are summarized in table 1. Age ($p<0.001$) and body mass ($p=0.005$) were greater in SP compared with YP. No significant changes in body mass were observed in SP or YP over the study duration.

Exercise Duration and Nutritional Status

The average exercise duration, energy intake and macronutrient intake over the combined 4-day study period are displayed in table 2. Exercise duration was 31.7% greater in SP compared with YP ($p<0.001$), however, energy intake was similar between groups ($p=0.800$). CHO intake, expressed relative to body mass and as % TEI, was greater in YP compared with SP ($p=0.006$, $p<0.001$, respectively), however no difference in CHO intake, expressed in absolute terms (g/day), was observed between groups ($p=0.144$). No difference in protein intake, expressed relative to body mass, was observed between groups ($p=0.286$), whereas protein intake, expressed as grams/day and % TEI, was higher for SP compared with YP ($p=0.007$, $p=0.005$ respectively). Dietary fat intake, expressed as % TEI, was higher in SP compared with YP ($p=0.017$).

Table 3 displays exercise duration, energy intake and macronutrient intake on the four individual study days. Exercise duration differed between days (within-subjects factor:

$p<0.001$), with the highest exercise duration on the training day. A significant day×group interaction effect for exercise duration was observed, whereby exercise duration was 13-fold higher for SP compared with YP on post-match day ($p<0.001$). A trend (within-subjects factor: $p=0.070$) for a difference in energy intake between days was observed and a significant day×group interaction effect for energy intake was detected over the 4-day period ($p=0.025$). However, Bonferroni post-hoc tests failed to locate pairwise differences.

CHO intake, expressed relative to body mass, showed no differences between days (within-subjects factor: $p=0.383$). A trend for a day×group interaction for CHO intake was detected ($p=0.080$). Protein intake, expressed relative to body mass, differed between days (within subject factor: $p=0.002$), with the highest intake recorded on the training day. However, no significant day×group interaction effect ($p=0.142$) was observed. Fat intake, expressed as % TEI, showed no differences between days (within-subjects factor: $p=0.553$) and no day×group interaction was observed ($p=0.095$).

Daytime pattern of dietary protein intake

Figure 1 displays protein intake on a meal-by-meal basis over the combined 4-day study period in SP and YP. The daily pattern of protein intake was similar between groups (no meal×group interaction; $p=0.193$). The percentage contribution of protein to total daily protein intake in the main meals (breakfast, lunch and dinner) and combined snacks was 20.7, 19.3, 30.8 and 29.0% in SP and 19.0, 18.9, 35.8 and 26.6% in YP, respectively (data not shown).

Table 4 presents protein intake on a meal-by-meal basis (g/meal) for each individual day. A significant day×group interaction effect of protein intake was observed for the lunch ($p<0.001$) and afternoon snack ($p=0.047$) meals. SP reported a higher protein intake compared with YP for lunch ($p=0.002$) and afternoon snack ($p=0.021$) on match-day, whereas YP reported a higher protein intake compared with SP for lunch on post-match day (p=0.029). No other statistically significant differences were observed between groups for any other meals.

Discussion

This novel descriptive study directly compared the nutritional status and daytime pattern of protein intake between senior professional and youth elite soccer players. Whereas reported dietary energy intake was similar between senior and youth players, macronutrient distribution showed partial differences between groups. Senior players failed to meet CHO recommendations on match and training days, whereas youth players met CHO recommendations on match, post-match, rest and training days. Conversely, both groups of players met or exceeded daily protein recommendations. As such, senior players compensated for inadequate CHO intake by consuming a higher protein intake compared with youth players. Alternatively, this observation suggests that senior players increased protein intake at the expense of carbohydrate intake on match and training days. A similar distribution pattern of daytime protein intake was observed between senior and youth players, with both groups approaching the daily recommendation (Moore et al., 2009; Witard et al., 2014) of 5-6 × ~20 g protein doses per meal in young adults. The dietary fat intake of both senior professional and young elite soccer players (29.0±3.6% and 25.7±3.4%, respectively) was lower than several comparable previous studies (Caccialanza et al., 2007; Garrido et al., 2007; Maughan, 1997; Rico-Sanz et al., 1998; Ruiz et al., 2005; Russell & Pennock, 2011), but comfortably met published recommendations (Rodriguez et al., 2009).

Directly comparable studies that assessed the nutritional status of soccer players across a similar competition period have reported energy intakes higher (Erp-Baart et. al. 1989; Ruiz et al., 2005), similar (Garrido et al., 2007; Russell & Pennock, 2011) and lower (Caccialanza et al., 2007) than reported in the present study. The use of different dietary recall approaches may account, at least in part, for differences in energy intakes reported between the present and past studies. Expanding this observation, in the present study, the energy intake of senior players tended (p=0.070) to be greater on match (3343 kcal/day) and training (3216 kcal/day) days compared with post-match (2732 kcal/day) and rest (2662 kcal/day) days. In contrast, energy intake of youth players remained relatively constant (2872-3008 kcal/day) across the 4-day period. Since energy expenditure was not measured in the present study, it was not possible to ascertain whether players maintained energy balance over the study period. In addition, including an independent method for validating the 24-h recall approach for assessing energy intake (Poslusna et al., 2009) would have strengthened our assessment of energy intake. However, no changes in body mass were observed in either senior or youth players over the study duration, implying that a state of energy balance was maintained. Nonetheless, in terms of energy intake *per se*, these data imply that senior players habitually adjust dietary energy intake on a daily basis dependent on exercise duration to a greater extent compared to youth players.

Our findings on CHO intake over the combined 4-day period align with previous studies (Garrido et al., 2007; Ruiz et al., 2005; Russell & Pennock, 2011). CHO intake on match and training days were either below, or were at the lower end, of recommendations (6-10 $g \cdot kg^{-1}$ $BM \cdot day^{-1}$ (Burke et al., 2011)). Playing positions differ in physical (playing style) and metabolic demands during training and match play (Bangsbo et al., 2006). Hence, whereas CHO intake was likely sufficient for the less active players, such as center backs and forwards, CHO intake was likely insufficient for more active players, such as midfielders, fullbacks and wingers (Burke et al., 2011). In the present study, the CHO intake of senior and youth player groups on recovery and rest days that consisted of recovery training and no training respectively, met scientific recommendations (3-5 $g \cdot kg^{-1}$ $BM \cdot day^{-1}$) (Burke et al., 2011). A 48 h post-match period has been shown to be insufficient for complete restoration of muscle glycogen stores after match play (Krustrup et al., 2011). In the present study, no fixtures were scheduled within 48-72 h after the reported match play recall. Thus, it may be argued that CHO intake reported on the post-match and rest day of the present study was sufficient when one match is played per week, but insufficient if, at certain points of the season, two games are scheduled in a week.

The dietary protein intake of senior and youth soccer players met, or exceeded, scientific recommendations (Phillips & Van Loon, 2011). The daily protein intake reported in the present study (1.7 and 1.9 $g \cdot kg^{-1}$ $BM \cdot day^{-1}$ for YP and SP, respectively), irrespective of study day, was consistent with similar previous studies in elite (Erdman et al., 2013; Garrido et al., 2007; Russell, & Pennock, 2011) and sub-elite (Ruiz et al., 2005) soccer players (1.5-2.1 $g \cdot kg^{-1}$ $BM \cdot day^{-1}$). Although mean values for the reported absolute protein intake was ~20% greater in senior- compared with youth players, this difference failed to reach statistical significance on a total daily or meal-by-meal basis. This observation was likely attributed to the decrease in statistical power associated with increasing the number of group comparisons, and thus degrees of freedom. Future descriptive studies with a larger sample size are warranted to comprehensively explore differences in dietary protein intake between youth and senior soccer players on a day-by-day and meal-by-meal basis.

In light of recent work regarding the impact of daytime pattern of protein intake for stimulating protein synthesis (Areta et al., 2013; Mamerow et al., 2014; Moore et al., 2012), the present study was novel in characterizing protein intakes of elite soccer players on a meal-by-meal basis. Evidence from acute metabolic studies (Moore et al., 2009; Witard et al., 2014) suggests that ingestion of ~20 g high quality protein, 5-6 times daily, stimulates a maximal daytime response of MPS in young adults, whereas a single serving of protein in excess of 20 g also stimulates non-anabolic processes, such as amino acid oxidation (Witard et al., 2014) Furthermore, recent research advocates ingestion of dietary protein before sleep for improving overnight recovery (Res et al., 2012). In the present study, senior and youth player groups reported protein intakes in excess of 20 g at breakfast, lunch and dinner. Senior players also consumed a protein quantity (15-20 g) approaching this optimal dose in afternoon and evening snacks, whereas YP reported a suboptimal protein intake of 10-15 g for afternoon and evening snacks. Taken together, these data suggest that, in contrast to the typical unbalanced pattern of daily protein feeding reported by the general population (De Castro, 1997; Valenzuela et al., 2013), soccer players showed a relatively balanced pattern of daily protein feeding.

Interestingly, the mean protein intake of breakfast, lunch and the afternoon snack was higher in senior compared with youth players. Only dinner showed higher percentages for youth (35.8%) compared with senior players (30.8%). This observation is likely attributed to the greater emphasis on nutrition support, in particular protein supplementation, for senior- compared with youth players. Senior players are provided with protein-based supplements on training and match-days whereas youth players are encouraged to consume, but are not provided with, protein-based supplements. Hence, whilst practitioner intervention likely influenced the total daily protein intake of senior professional soccer players to a greater extent than youth elite soccer players, this increased protein intake appeared to occurr at the expense of CHO intake on training and match days.

Conclusion

Nutritional status in senior professional and youth elite soccer players shows similarity in terms of energy intake, but differences in macronutrient distribution. Consistent with our original hypothesis, senior players failed to meet recommended scientific guidelines for CHO intake during match and training days. Instead, protein intake was increased at the expense of carbohydrate intake. Elite soccer players, irrespective of youth elite or senior professional status, met dietary protein recommendations on match-, recovery-, rest- and training days and similarly reported a 'balanced' daytime protein meal pattern.

Practical message

CHO intake in elite soccer should be adjusted according to the physical (largely dependent on playing position) and metabolic demands of the day. The successful periodization of dietary CHO into a typical weekly training and match-day program requires thorough sports nutrition knowledge, organization and preparation. We recommend that scientific guidelines on protein intake remain cognizant of the potential impact on decreasing CHO intake and should take into consideration an assessment of protein intake pattern for optimizing SMPR during recovery.

List of abbreviations

SP: senior professional soccer players; YP: youth elite soccer players; SMPR: skeletal muscle protein remodelling; MPS: muscle protein synthesis; TEI: total energy intake.

Authors' contributions

AB designed the study, collected and interpreted data and drafted the manuscript. NB analyzed data. KR collected data. FW co-developed Compl-eat^{TM}, OW designed the study and edited the manuscript. None of the authors have a financial conflict of interest to declare. All authors gave final approval on the manuscript.

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References

Areta, J. L., Burke, L.M., Ross, M.L., Camera, D.M., West, D.W.D., Broad, E.M., Jeacocke, N.A., Moore, D.R., Stellingwerff, T., Phillips, S.M., Hawley, J.H., & Coffey, V.G. (2013). Timing and distritbution of protein ingestion during prolonged recovery from rsistance exercise alters myofibrillar protein sybthesis. *Journal of Physiology, 591*(9), 2319-2331.

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football players. *Journal of Sports Sciences, 24*(7), 665-674.

Bergström, J., Hermansen, L., Hultman, E., & Saltin, B. (1967). Diet, muscle glycogen and physical performance. *Acta Physiologica Scandinavica, Oct-Nov 71(2),* 140-150.

Bingham, S. A., Cassidy, A., Cole, T.J., Welch, A., Runswick, S.A., Black, A.E., Thurnham, D., Bates, C., Khaw, K.T., Key, T.J.A., & Day, N.E. (1995). Validation of weighed records and other methods of dietary assessment using the 24 h urine nitrogen technique and other biological markers. *British Journal of Nutrition, 73*, 531-550.

Burke, L. M., Hawley, J.A., Wong, S.H., & Jeukendrup, A.E. (2011). Carbohydrates for training and competition. *Journal of Sports Sciences, 29*(Suppl 1), S17-S27.

Burke, L. M., Loucks, A.B., & Broad, N. (2006). Energy and carbohydrate for training and recovery. *Journal of Sports Sciences*, *24*(7), 675-685.

Caccialanza, R., Cameletti, B., & Cavallaro, G. (2007). Nutritional intake of young Italian high-level soccer players: under-reporting is the essential outcome. *Journal of Sports Science and Medicine, 6*, 538-542.

Conway, J. M., Ingwersen, L.A., Vinyard, B.T., & Moshfegh, A.J. (2003). Effectiveness of the US department of agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women. *American Journal of Clinical Nutrition, 77*, 1171-1178.

Conway, J. M., Ingwersen, L.A., & Moshfegh, A.J. (2004). Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. *Journal of the American Dietetic Association, 104*, 595-603.

De Castro, J.M. (1997). Socio-cultural determinants of meal size and frequency. *British Journal of Nutrition*, *77*(Suppl.1), S39-S55.

Erdman, K. A., Tunnicliffe, J., Lun, V.M., & Reimer, R.A. (2013). Eating patterns and composition of meals and snacks in elite canadian athletes. *International Journal of Sport Nutrition and Exercise Metabolism, 23*, 210-219.

Erp-Baart, A. M. J. v., Saris, W.H.M., Binkhorts, R.A., Vos, J.A., & Elvers, J.W.H. (1989). Nationwide survey on nutritional habits in elite athletes: Part I. Energy, carbohydrate, protein and fat intake. *International Journal of Sports Medicine, 10*, S3-S10.

Garrido, G., Webster, A.L., & Chamorro, M. (2007). Nutritional adequacy of different menu settings in elite Spanish adolescent soccer players. *International Journal of Sport Nutrition and Exercise Metabolism, 17*, 421-432.

Grandjean, A. C. (1989). Macronutrient intake of US athletes compared with the general population and recommendations made for athletes. *The American Journal of Clinical Nutrition, 49*, 1070-1076.

Hargreaves, M. (1999). Metabolic responses to carbohydrate ingestion: Effects on exercise performance. In D.R. Lamb & R. Murray (Eds.), The Metabolic Basis of Performance in Exercise and Sport. Perspectives in exercise science and sports medicine (pp. 93-124). Carmel, IN: Cooper.

Holway, F. E., & Spriet, L.L. (2011). Sport-specific nutrition: practical strategies for team sports. *Journal of Sports Sciences, 29*(sup1), S115-S125.

Krustrup, P., Ørtenblad, N., Nielsen, J., Nybo, L., Gunnarsson, T.P., Marcello Iaia, F., Madsen, K., Stephens, F., Greenhaff, P., & Bangsbo, J. (2011). Maximal voluntary contraction force, SR function and glycogen resynthesis during the first 72 h after a high-level competitive soccer game. *European Journal of Applied Physiology, 111*, 2987-2995.

Mamerow, M. M., Mettlet, 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. *The Journal of Nutrition, 144*(6), 876-880.

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

Moore, D. R., Areta, J., Coffey, V.G., Stellingwerff, T., Phillips, S.M., Burke, L.M., Cléroux, M., Godin, JP., & Hawley, J.A. (2012). Daytime pattern of post-exercise protein intake affects whole-body protein turnover in resistance-trained males. *Nutrition and Metabolism, 9*(1), 91.

Moore, D. R., Robinson, M.J., Fry, J.L., Tang, J.E., Glover, E.I., Wilkinson, S.B., Prior, T., Tarnopolsky, M.A., & Phillips, S.M. (2009). Ingested protein dose response of muscle and albumin protein synthesis after resistance exercise in young men. *The American Journal of Clinical Nutrition, 89*, 161-168.

Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2012). Recovery in soccer part 1: post-match fatigue and time course of recovery. *Sports Medicine, 42*(12), 997-1015.

Phillips, S. M., & Van Loon, L.J.C. (2011). Dietary protein for athletes: from requirements to optimum adaptation. *Journal of Sports Sciences, 29*(sup1), S29-S38.

Poslusna, K., Ruprich, J., Vries de, J.H.M., Jakubikova, M., & Veer van't, P. (2009). Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. *British Journal of Nutrition, 101*(Suppl. 2), S73-S85.

Res, P. T., Groen, B., Pennings, B., Beelen, M., Wallis, G.A., Gijsen, A.P., Senden, J.M.G., & VanLoon, L.J.C. (2012). Protein ingestion before sleep improves postexercise overnight recovery. *Medicine and Science in Sports and Exercise, 44*(8), 1560-1569.

Rico-Sanz, J., Frontera, W.R., Molé, P.A., Rivera, M.A., Rivera-Brown, A., & Meredith, C.N. (1998). Dietary and performance assessment of elite soccer players during a period of intense training. *International Journal of Sport Nutrition, 8,* 230-240.

Rodriguez, N. R., DiMarco, N.M., & Langley, S. (2009). Nutrition and athletic performance. *Medicine and Science in Sports and Exercise, 41*(3), 709-731.

Rollo, I. (2014). Carbohydrate: the football fuel. *Sports Science Exchange, 27*(127), 1-8.

Ruiz, F., Irazusta, A, Gil., S., Irazusta, J. Casis, L. & Gil, J. (2005). Nutritional intake in soccer players of different ages. *Journal of Sports Sciences, 23*(3), 235-242.

Russell, M., & Kingsley, M. (2014). The efficacy of acute nutritional interventions on soccer skill performance. *Sports Medicine, 44*, 957-970.

Russell, M., & Pennock, A. (2011). Dietary analysis of young professional soccer players for 1 week during the competitive season. *Journal of Strength and Conditioning Research, 25*(7), 1816-1823.

Shephard, R. J. (1999). Biology and medicine of soccer: an update. *Journal of Sports Sciences, 17*(10), 757-786.

Silva, J. R., Ascensão, A., Marques, F., Seabra, A., Rebelo, A., & Magalhães, J. (2013). Neuromuscular funtion, hormonal and redox status and muscle damage of professional soccer players after a high-level competitive match. *European Journal of Applied Physiology*.

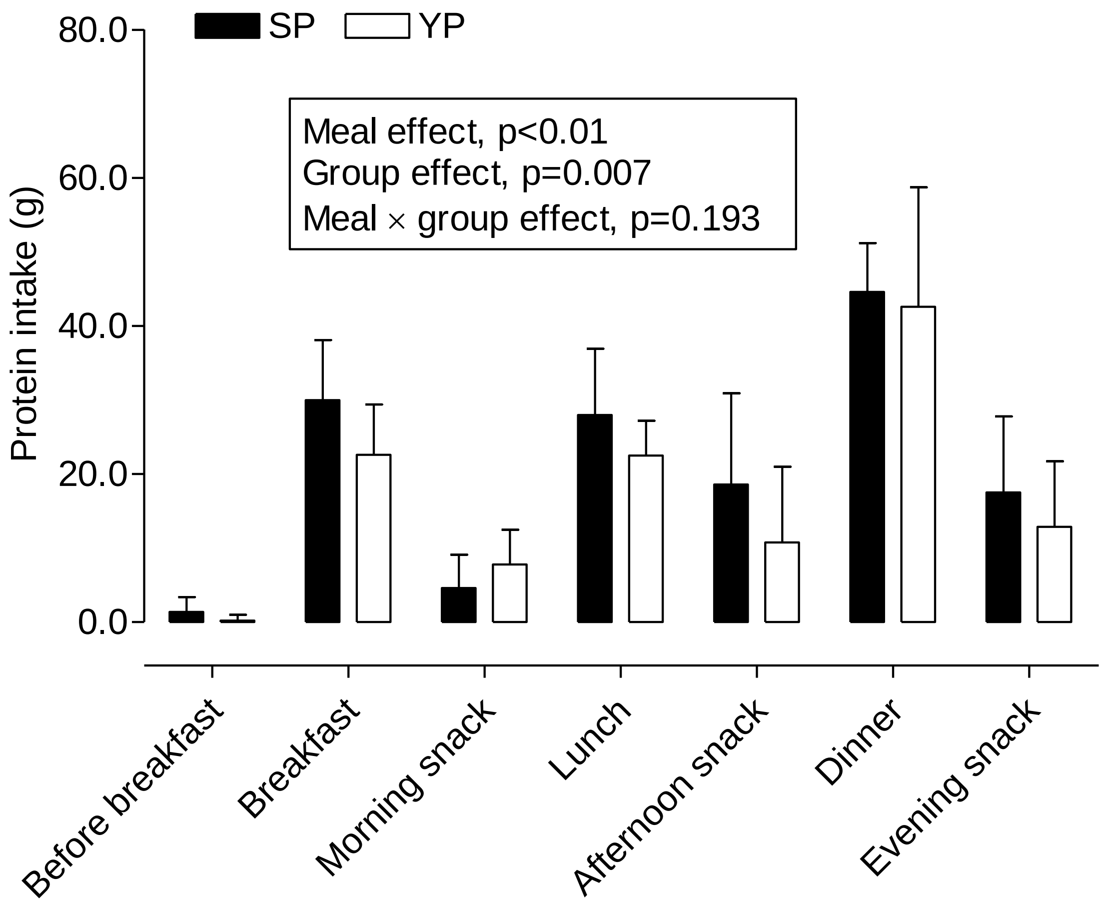
Tipton, K. D., & Witard, O.C. (2007). Protein requirements and recommendations for athletes: relevance of ivory tower arguments for practical recommendations. *Clinics in Sports Medicine, 26*(1), 17-36.

Tipton, K. D., & Wolfe, R.R. (2004). Protein and amino acids for athletes. *Journal of Sports Sciences, 22,* 65-79.

Valenzuela, R.E., Ponce, J.A., Morales-Figueroa, G.G., Muro, K.A., Carreón, V.R., & Alemán-Mateo, H. (2013). Insufficient amounts and inadequate distribution of dietary protein intake in apparently healthy older adults in a developing country: implications for dietary strategies to prevent sarcopenia. *Clinical Interventions in Aging, 8,* 1143-1148.

Witard, O.C., Jackman, S.R., Breen, L., Smith, K., Selby, A., & Tipton, K. D. (2014). Myofibrillar muscle protein synthesis rates subsequent to a meal in response to increasing doses of whey protein at rest and after resistance exercise. *The American Journal of Clinical Nutrition, 99,* 86-95.

Figure 1. Average protein intake pattern over the combined 4-day study period (match, post-match, rest and training day)



Note: SP = senior professional soccer players; YP = youth elite soccer players, before breakfast constitute all foods and drinks consumed between wake up and breakfast, morning snack constitute all foods and drinks (including sport supplements) consumed between breakfast and lunch, afternoon snack constitute all foods and drinks (including sport supplements) consumed between lunch and dinner, evening snack constitute all foods and drinks (including sport supplements) consumed between dinner and bedtime. Data are expressed as means ± SD.

Table 1. *Player demographics and playing positions*

	Total (*n*=29)	SP (*n*=14)	YP (*n*=15)	*p* values
Age (yr)	19.9±3.8	22.8±3.7*	17.3±1.1*	<0.001
Body height (cm)	179.7±7.0	181.3±7.6	178.2±6.2	0.230
Body weight (kg)	72.8±8.2	77.0±8.6*	68.9±5.7*	0.005
Center backs	7	4	3	N/A
Full backs	5	2	3	N/A
Midfielders	10	5	5	N/A
Wingers	4	1	3	N/A
Forwards	3	2	1	N/A

Note: *significant difference between SP and YP. Data are expressed as means ± SD

Table 2. *Average exercise duration, energy intake and macronutrient intake over the combined 4-day study period*

	Total (*n*=29)	SP (*n*=14)	YP (*n*=15)	*p* values
Exercise (min / day)	49.5±10.8	56.5±8.0	42.9±8.8	<0.001*
Energy (kcal / day)	2963±516	2988±583	2938±465	0.800
Carbohydrate				
g/day	389±84	365±76	411±87	0.144
$g{\cdot}kg^{-1}{\cdot}day^{-1}$	5.4±1.3	4.7±0.7	6.0±1.5	0.006*
%TEI	52.2±5.5	48.7±3.3	55.6±5.1	<0.001*
Protein				
g/day	132±26	145±24	119±22	0.007*
$g{\cdot}kg^{-1}{\cdot}day^{-1}$	1.8±0.4	1.9±0.3	1.7±0.4	0.286
%TEI	18.1±3.2	19.7±2.4	16.6±3.1	0.005*
Fat				
g/day	90±21	97±26	84±14	0.100
$g{\cdot}kg^{-1}{\cdot}day^{-1}$	1.2±0.3	1.3±0.3	1.2±0.2	0.745
%TEI	27.3±3.8	29.0±3.6	25.7±3.4	0.017*

Note: *significant difference between SP and YP (*p* values shown). Data are expressed as mean ± SD

Table 3. *Exercise duration, energy intake and macronutrient intakes on the four individual study days*

		Group	Match day	Post-match day	Rest day	Training day	*p* values: Day effect	*p* values: Group effect	*p* values: Day × group effect
Exercise	min/day	SP (n=14)	69.9±32.5[a,b,d]	52.1±16.6[a,b]	0.0±0.0[c]	103.9±21.6[a,d]	<0.001[1,2]	<0.001	0.029[¶]
		YP (n=15)	60.9±34.0[a,d]	4.0±15.5[b,c]	0.0±0.0[b,c]	106.7±42.8[a,d]			
Energy	kcal/day	SP (n=14)	3343±909	2732±481	2662±680	3216±834	0.070	0.800	0.025
		YP (n=15)	2872±690	3008±700	2910±806	2964±467			
Carbohydrate	g/day	SP (n=14)	406±129	350±92	308±89	396±118	0.301	0.144	0.062
		YP (n=15)	407±112	403±120	427±141	405±95			
	$g \cdot kg^{-1} \cdot day^{-1}$	SP (n=14)	5.3±1.5	4.5±1.0	4.0±0.9	5.1±1.3	0.383	0.006	0.080
		YP (n=15)	6.0±1.9	5.9±1.9	6.3±2.3	6.0±1.6			
	%TEI	SP (n=14)	48.5±6.4	50.7±6.9	46.4±7.3	49.1±6.9	0.974	<0.001	0.073
		YP (n=15)	56.4±6.9	53.4±8.0	58.1±5.7	54.3±9.2			
Protein	g/day	SP (n=14)	152±30[a,b,c,d]	125±22[a,b,c]	136±40[a,b,c,d]	166±41[a,c,d]	0.001[1]	0.007	0.104
		YP (n=15)	110±32	115±30	119±33	133±32			
	$g \cdot kg^{-1} \cdot day^{-1}$	SP (n=14)	2.0±0.4[a,b,c,d]	1.6±0.3[a,b,c]	1.8±0.5[a,b,c,d]	2.2±0.6[a,c,d]	0.002[1]	0.286	0.142
		YP (n=15)	1.6±0.5	1.7±0.5	1.8±0.5	1.9±0.5			
	%TEI	SP (n=14)	18.7±3.2	18.6±3.9	20.6±4.0	21.0±3.6	0.004[2]	0.005	0.918
		YP (n=15)	15.8±4.1[a,b,c]	15.5±2.8[a,b,c,d]	16.8±3.6[a,b,c,d]	18.2±4.8[b,c,d]			
Fat	g/day	SP (n=14)	112±41	85±25	91±34	100±41	0.257	0.089	0.060
		YP (n=15)	82±32	97±32	72±24	83±30			
	$g \cdot kg^{-1} \cdot day^{-1}$	SP (n=14)	1.5±0.5	1.1±0.3	1.2±0.4	1.3±0.5	0.282	0.745	0.067
		YP (n=15)	1.2±0.5	1.4±0.5	1.1±0.4	1.2±0.5			
	%TEI	SP (n=14)	29.9±6.0	28.1±6.8	30.4±6.9	27.5±7.0	0.553	0.017	0.095
		YP (n=15)	25.7±6.5	28.9±7.1	22.6±4.6	25.4±8.0			

Note: SP = senior professional soccer players; YP = youth elite soccer players, [1]Means (SD) within SP with different superscript letters are significantly different from each other $p<0.01$, [2]Means (SD) within YP with different superscript letters are significantly different from each other $p<0.01$, [¶] significant differences between SP and YP on post-match day $p<0.001$. Data are expressed as mean ± SD.

Table 4. *Daily protein (total g) meal distribution on the four selected days*

	Match day	Post-match day	Rest day	Training day	*p* values		
					Day effect	Group effect	Day × group effect
Before breakfast							
SP (n=14)	0.0±0.0	1.6±4.3	2.0±3.7	2.0±3.9	0.268	0.036	0.361
YP (n=15)	0.0±0.0	0.8±3.0	0.0±0.0	0.0±0.1			
Breakfast							
SP (n=14)	28.9±9.1	27.5±10.1	31.3±11.9	32.2±15.2	0.441	0.012	0.309
YP (n=15)	26.7±9.1	20.6±7.8	20.9±10.9	22.2±11.8			
Morning snack							
SP (n=14)	1.6±3.2	4.4±6.7	2.4±6.0	10.3±15.2	0.160	0.072	0.304
YP (n=15)	9.2±8.5	5.3±7.6	7.5±11.6	9.3±11.0			
Lunch							
SP (n=14)	36.5±18.7	15.9±11.3	30.5±14.4	28.9±12.5	0.264	0.045	<0.001[¶,§]
YP (n=15)	17.3±7.2	26.6±13.5	22.8±13.4	23.3±8.2			
Afternoon snack							
SP (n=14)	23.3±25.6	19.4±18.4	8.7±11.4	22.9±21.3	0.562	0.076	0.047[*]
YP (n=15)	4.9±9.0	11.6±24.2	14.5±16.7	12.3±10.5			
Dinner							
SP (n=14)	40.5±18.8	39.2±11.0	45.1±15.5	53.7±20.1	0.140	0.662	0.794
YP (n=15)	42.8±34.6	39.5±18.1	41.0±18.3	47.0±18.4			
Evening snack							
SP (n=14)	21.2±21.1	16.6±11.0	16.2±14.1	15.9±11.7	0.662	0.204	0.189
YP (n=15)	9.4±11.0	10.7±12.8	12.5±12.2	18.8±18.8			

Note: SP = senior professional soccer players; YP = youth elite soccer players, [¶]p=0.002 denotes differences between SP and YP for lunch on match day, [§]p=0.029 denotes differences between SP and YP for lunch on post-match day, [*]p=0.021 denotes differences between SP and YP for afternoon snack on match day. Data are expressed as *mean ± SD*.