



# University of HUDDERSFIELD

## University of Huddersfield Repository

Naughton, Robert, Drust, Barry, O'Boyle, Andy, Morgans, Ryland, Abayomi, Julie, Davies, Ian G., Morton, James P. and Mahon, Elizabeth

Daily Distribution of Carbohydrate, Protein and Fat Intake in Elite Youth Academy Soccer Players Over a 7-day Training Period

### Original Citation

Naughton, Robert, Drust, Barry, O'Boyle, Andy, Morgans, Ryland, Abayomi, Julie, Davies, Ian G., Morton, James P. and Mahon, Elizabeth (2016) Daily Distribution of Carbohydrate, Protein and Fat Intake in Elite Youth Academy Soccer Players Over a 7-day Training Period. *International Journal of Sport Nutrition and Exercise Metabolism*, 26 (5). pp. 473-480. ISSN 1526-484X

This version is available at <http://eprints.hud.ac.uk/id/eprint/29467/>

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: [E.mailbox@hud.ac.uk](mailto:E.mailbox@hud.ac.uk).

<http://eprints.hud.ac.uk/>



**Daily distribution of carbohydrate, protein and fat intake in elite youth academy soccer players over a 7-day training period**

Journal:	<i>International Journal of Sport Nutrition &amp; Exercise Metabolism</i>
Manuscript ID	IJSNEM.2015-0340.R1
Manuscript Type:	Original Research
Keywords:	nutrition, metabolism, sport

SCHOLARONE™  
Manuscripts

Review

1 **Daily distribution of carbohydrate, protein and fat intake in elite youth academy**  
2 **soccer players over a 7-day training period**

3 Robert J. Naughton<sup>1</sup>, Barry Drust<sup>2,3</sup>, Andy O'Boyle<sup>3</sup>, Ryland Morgans<sup>3</sup>, Julie  
4 Abayomi<sup>1</sup>, Ian G. Davies<sup>1</sup>, James P. Morton<sup>2</sup> and Elizabeth Mahon<sup>1</sup>

5 <sup>1</sup>School of Sports Studies, Leisure and Nutrition

6 Liverpool John Moores University

7 Liverpool

8 L17 6BD

9 UK

10

11 <sup>2</sup>Research Institute for Sport and Exercise Sciences

12 Liverpool John Moores University

13 Tom Reilly Building

14 Byrom St Campus

15 Liverpool

16 L3 3AF

17 UK

18

19 <sup>3</sup>Liverpool Football Club

20 Melwood Training Ground

21 Deysbrook Lane

22 Liverpool

23 L12 8SY

24 UK

25

26 **Running head:** Nutrition, youth soccer, exercise metabolism

27 **Word Count:** 3250

28 Address for correspondence:

29 Robert Naughton

30 <sup>1</sup>School of Sports Studies, Leisure and Nutrition

31 Liverpool John Moores University

32 Liverpool

33 L17 6BD

34 United Kingdom

35 Email: [R.Naughton@2008.ljmu.ac.uk](mailto:R.Naughton@2008.ljmu.ac.uk)

36

37

38

39

40

41

42

43

44

45

46

47 **Abstract**

48 While traditional approaches to dietary analysis in athletes have focused on total daily  
49 energy and macronutrient intake, it is now thought that daily distribution of these  
50 parameters can also influence training adaptations. Using seven-day food diaries, we  
51 quantified the total daily macronutrient intake and distribution in elite youth soccer  
52 players from the English Premier League in U18 ( $n=13$ ), U15/16 ( $n=25$ ) and U13/14  
53 squads ( $n=21$ ). Total energy ( $43.1\pm 10.3$ ,  $32.6\pm 7.9$ ,  $28.1\pm 6.8$  kcal $\cdot$ kg $^{-1}\cdot$ day $^{-1}$ ), CHO  
54 ( $6\pm 1.2$ ,  $4.7\pm 1.4$ ,  $3.2\pm 1.3$  g $\cdot$ kg $^{-1}\cdot$ day $^{-1}$ ) and fat ( $1.3\pm 0.5$ ,  $0.9\pm 0.3$ ,  $0.9\pm 0.3$  g $\cdot$ kg $^{-1}\cdot$ day $^{-1}$ )  
55 intake exhibited hierarchical differences ( $P<0.05$ ) such that U13/14>U15/16>U18.  
56 Additionally, CHO intake in U18s was lower ( $P<0.05$ ) at breakfast, dinner and snacks  
57 when compared with both squads but no differences were apparent at lunch.  
58 Furthermore, the U15/16s reported lower relative daily protein intake than the  
59 U13/14s and U18s ( $1.6\pm 0.3$  vs.  $2.2\pm 0.5$ ,  $2.0\pm 0.3$  g $\cdot$ kg $^{-1}$ ). A skewed distribution  
60 ( $P<0.05$ ) of daily protein intake was observed in all squads, with a hierarchical order  
61 of dinner ( $\sim 0.6$  g $\cdot$ kg $^{-1}$ ) > lunch ( $\sim 0.5$  g $\cdot$ kg $^{-1}$ ) > breakfast ( $\sim 0.3$  g $\cdot$ kg $^{-1}$ ). We conclude  
62 elite youth soccer players do not meet current CHO guidelines. Although daily protein  
63 targets are achieved, we report a skewed daily distribution in all ages such that  
64 dinner>lunch>breakfast. Our data suggest that dietary advice for elite youth players  
65 should focus on both total daily macronutrient intake and optimal daily distribution  
66 patterns.

67

68

69

## 70 Introduction

71 The function of soccer academies is largely to produce players who can progress to  
72 and represent the club's senior first team, and thereby reduce the requirement for  
73 clubs to buy or sell players in an attempt to achieve financial targets (Wrigley *et al.*,  
74 2014). To support the high training loads (Wrigley *et al.*, 2012) and developmental  
75 goals such as muscle hypertrophy (Milsom *et al.*, 2015), it is essential players  
76 consume the correct quantity and type of macronutrients. Few studies have  
77 investigated habitual energy intakes and dietary habits of elite youth soccer players  
78 (Boisseau *et al.*, 2002 & 2007; LeBlanc *et al.*, 2002; Ruiz *et al.*, 2005; Iglesias-  
79 Gutierrez *et al.*, 2005) with just two in the UK (Russell and Pennock, 2011; Briggs *et*  
80 *al.*, 2015). These studies have typically been limited to reports of total daily energy  
81 and macronutrient intake, often concluding that elite youth soccer players habitually  
82 don't meet their energy requirements (Boisseau *et al.* 2002; LeBlanc *et al.*, 2002; Ruiz  
83 *et al.*, 2005; Russell and Pennock, 2011; Briggs *et al.*, 2015).

84 In addition to the quantification of daily energy and macronutrient intake, it is  
85 important to consider timing of intake in relation to training sessions (Burke, 2010;  
86 Mori, 2014), main meals (Garaulet and Gomez-Abellan, 2014; Johnston, 2014) and  
87 sleep (Lane *et al.*, 2015). Whilst this is most well documented for carbohydrate  
88 (CHO) intake in order to fuel training and matches (Goedecke *et al.*, 2013;  
89 Jeukendrup, 2014) and promote glycogen re-synthesis (Zehnder *et al.*, 2001;  
90 Gunnarsson *et al.*, 2013), recent data suggests that the daily distribution of protein  
91 intake is critical for optimizing components of training adaptations such as muscle  
92 protein synthesis (MPS) (Areta *et al.*, 2013; Mamerow *et al.*, 2014). Recent data has  
93 highlighted the importance of quantity and timing of protein intake in elite youth  
94 soccer players. Milsom *et al.* (2015) demonstrated that such populations typically

95 present with approximately 6 kg less lean muscle mass than adult professional soccer  
96 players. When taken together, these data suggest that dietary surveys of elite youth  
97 soccer players should not only quantify total daily energy and macronutrient intake  
98 but should also report the timing of nutrient ingestion, thereby having important  
99 practical implications for fuelling adequately, promoting training adaptations and  
100 optimizing recovery.

101 Therefore, the aims of the present study were two-fold: 1) to quantify the total daily  
102 energy and macronutrient intakes of elite youth UK academy players of different ages  
103 (U13/14, U15/16 and U18 playing squads) and 2) to quantify the daily distribution of  
104 energy and macronutrient intake. In accordance with the higher absolute body masses  
105 and training loads of the U18 squads (Wrigley *et al.*, 2012), we hypothesised that this  
106 squad would report higher absolute daily energy and macronutrient intakes in  
107 comparison to the U13/14s and U15/16s. Furthermore, based on the habitual eating  
108 patterns of both athletic and non-athletic populations (Mamerow *et al.*, 2014), we  
109 hypothesised that all squads would report an uneven daily distribution of  
110 macronutrient intakes, particularly for daily protein intake.

## 111 **Methodology**

### 112 *Participants*

113 Elite youth soccer players were recruited from a local English Premier League (EPL)  
114 club's academy. Researchers provided a presentation and participant information  
115 sheets to invite players from the U13-18s to participate in the study. Ninety-one  
116 players were initially recruited, however 32 were withdrawn due to incomplete diary  
117 entry, leaving a sample size of 59. All participants gave informed consent and ethical

118 permission was obtained from the Liverpool John Moores University Ethics  
119 Committee.

120 Participants were subsequently categorised into the following squads; U18s ( $n=13$ ),  
121 U15/16 ( $n=25$ ) and U13/14 ( $n=21$ ). The mean ( $\pm$ SD) body mass (determined by scale  
122 mass – Seca, Hamburg, Germany) and height (determined by stadiometry) were  
123 recorded to the nearest 0.1kg and cm, respectively, for each squad and are displayed in  
124 Table 1, along with habitual training time albeit collected 2-3 weeks after this study  
125 period (Brownlee *et al.* Unpublished Data). Data collection occurred during a 7 day  
126 training period of the 2014-15 season, during which no competitive matches took  
127 place.

#### 128 *Dietary Intake*

129 Participants were asked to record everything they consumed in a food diary for 7-  
130 consecutive days. This time frame was justified by previous research suggesting that  
131 7-days provides a more accurate estimation of habitual nutritional intake than a single-  
132 or 4-day recording (Magkos & Yannakoulia, 2003). Additionally, unpublished pilot  
133 research on the current study's population displayed a high completion rate (75%)  
134 over the 7-days. To promote high ecological validity, researchers made no attempt to  
135 influence the player's diets. Upon giving consent, players attended a presentation that  
136 gave detailed instructions on how to fill out the dietary diary. Parents and guardians of  
137 the U13/14s also attended, as it was evidenced from pilot research that they were  
138 likely to be responsible for completion of the diaries at this age. Participants were  
139 asked to provide as much detail as possible, including the type of day it was with  
140 respect to their soccer activity (rest, match, or training day), the commercial brand  
141 names of the food/drink, cooking/preparation methods, and time of consumption.



142 Time of consumption was used to distinguish between meals; breakfast (main meal  
143 consumed between 6-9.30am), lunch (main meal consumed between 11.30-1.30pm),  
144 dinner (main meal consumed between 5-8pm), and snacks (foods consumed between  
145 main meals). Additionally in table 2 the time and frequency of snack consumption for  
146 each team is displayed. Supplements were defined as foods/drinks/powders that were  
147 purposefully taken to provide an additional source of any one or combination of  
148 macronutrients (e.g. Whey Protein). Participants were asked to quantify the portion of  
149 the foods and fluids consumed by using standardised household measures or, where  
150 possible, referring to the weight/volume provided on food packages, or by providing  
151 the number of items of a predetermined size. Upon return of the food diary the  
152 primary researcher checked for any cases of missing data and asked participants for  
153 clarification.

#### 154 *Data Analysis*

155 Food diary data was analysed using Nutritics software (version 3.74 professional  
156 edition, Nutritics Ltd., Co. Dublin, Ireland). All analyses were carried out by a single  
157 trained researcher so that potential variation of data interpretation was minimised  
158 (Deakin, 2000). Total absolute, and relative to body mass (BM), intakes of energy  
159 (kcal), CHO, protein and fats were calculated. All data were assessed for normality of  
160 distribution according to the Shapiro-Wilk's test. Statistical comparisons between  
161 squads' total energy and macronutrient intakes were performed according to a one-  
162 way between-groups analysis of variance (ANOVA) or, for non-parametric data, the  
163 Kruskal-Wallis test. Where significant differences of the ANOVA were present,  
164 Tukey post-hoc analysis was conducted to locate specific differences. For non-normal  
165 data, post-hoc analysis was performed using multiple Mann-Whitney U tests with a  
166 Bonferroni adjustment. For energy and macronutrient distribution across separate

167 meals, a two-way ANOVA was employed and a Tukey post-hoc analysis was  
168 conducted where appropriate. Where a significant main difference for age was  
169 reported, a one-way ANOVA or, the Kruskal-Wallis test was performed, to assess at  
170 which meal the difference occurred. All analyses were completed using SPSS for  
171 Windows (version 20, SPSS Inc., Chicago, IL) where  $P < 0.05$  was indicative of  
172 statistical significance.

173 Data is presented as mean $\pm$ SD. In the results section, *absolute* refers to the total  
174 absolute daily intake and *relative* refers to when the absolute data has been normalized  
175 to each participants' BM (i.e.  $\text{g}\cdot\text{kg}^{-1}$  BM).

## 176 **Results**

### 177 *Daily Energy and macronutrient total and relative daily intake*

178 No significant difference was found for absolute daily energy ( $P=0.92$ ), CHO  
179 ( $P=0.70$ ) or fat ( $P=0.18$ ) intake between squads. However, absolute daily intake of  
180 protein showed a significant difference ( $P < 0.01$ ) between squads, both the U13/14s  
181 and U15/16s squads reported lower intakes than the U18 squad ( $P=0.01$ ). In contrast  
182 to the absolute data, significant differences were observed for all variables when  
183 expressed in relative amounts ( $P < 0.05$ ). For relative energy, CHO and fat intake, the  
184 U13/14s values were significantly higher compared to both the U15/16s and U18s  
185 ( $P < 0.01$  for all comparisons). The U13/14 and U18 squads were both significantly  
186 higher in relative protein compared to the U15/16s ( $P < 0.01$ ). Additionally, the  
187 U15/16s had a significantly higher relative CHO intake in comparison to the U18s  
188 ( $P=0.01$ ) (Table 3).

### 189 *The distribution of energy and macronutrients across separate meals*

190 A significant difference for distribution across meals was found for all variables for  
191 both absolute and relative intake ( $P<0.01$ ). For energy, both absolute and relative  
192 intake at breakfast was significantly lower than intake at lunch and dinner ( $P<0.01$ ).  
193 Dinner was significantly higher ( $P<0.01$ ) than snacks whether expressed as absolute  
194 or relative. CHO intake at breakfast was significantly lower than lunch and snacks for  
195 both absolute and relative intake ( $P<0.05$ ), and for absolute dinner intake ( $P=0.03$ ),  
196 but not for relative intake ( $P=0.06$ ) (Figure 1).

197 Protein distribution was found to be significant between all meals ( $P<0.05$ ) for  
198 absolute intake, and PRO at breakfast was significantly lower compared to both lunch  
199 and dinner for relative intake ( $P<0.01$ ). Additionally, relative protein intake at dinner  
200 was significantly higher compared to snacks ( $P<0.01$ ). For fat distribution, both  
201 absolute and relative intake at dinner was significantly higher ( $P<0.01$ ) than both  
202 breakfast and snacks ( $P<0.01$ ) (Figure 1).

203 A significant difference was observed between-squads for distribution of absolute  
204 CHO and PRO intake ( $P<0.01$ ). Specifically, for breakfast and lunch the U18s  
205 reported a significantly higher intake of absolute PRO intake compared with the  
206 U13/14s and U15/16s ( $P<0.01$ ), but when considering relative protein, the U13/14s  
207 had a significantly higher ( $P<0.05$ ) intake at dinner and snacks compared to their  
208 older counterparts, which was also true for relative fat intake. Furthermore, a  
209 significantly lower intake of both absolute and relative CHO in comparison to the  
210 U15/16s at breakfast was observed ( $P<0.01$ ), and with dinner and snacks but only for  
211 relative intake compared to the younger groups (Figure 1). The U13/14s have a  
212 significantly higher intake of relative energy for every meal compared to the U15/16s  
213 and U18s ( $P<0.05$ ).

214 *Supplements.*

215 No statistical analysis was performed for supplements as intake within the U13/14 and  
216 U15/16 ( $n=3$ ) was negligible. Within the U18s mean daily intake from supplements  
217 were: Energy  $89.2\pm 110.4$  kcal, CHO  $2.5\pm 6.5$  g, Protein  $15.1\pm 17.3$  g, and Fat  $0.8\pm 1.1$   
218 g.

## 219 **Discussion**

220 The aims of the present study were to simultaneously quantify the total daily  
221 macronutrient intake and daily distribution in elite youth soccer players of differing  
222 ages. **With the exception of protein, we observed no significant difference in total**  
223 **absolute energy and macronutrient intake between squads.** However, differences in  
224 macronutrient intake were readily apparent when expressed relative to BM. We also  
225 report for the first time a skewed daily distribution of macronutrient intakes in elite  
226 male youth soccer players (irrespective of age), an effect that was especially pertinent  
227 for protein intake. Given the requirement for young soccer players to gain lean muscle  
228 mass, such data may have practical implications for helping to promote training  
229 adaptations.

230 The values reported here for both total daily energy and CHO intake compare well to  
231 those previously reported for players of similar ages (Boisseau *et al.*, 2002; Ruiz *et*  
232 *al.*, 2007). For example, Boisseau *et al.* (2002) reported energy intakes of  $38.9\pm 4.4$   
233  $\text{kcal}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$  and Ruiz *et al.* (2007) reported CHO intakes of  $5.9\pm 0.4$   $\text{g}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ ,  
234 both of which are similar to the U15/16s in the present study (Table 3). A consistent  
235 theme within the literature appears to be that elite youth soccer players consume lower  
236 energy intakes than likely daily energy requirements, thus potentially compromising  
237 performance. While no differences between absolute energy and CHO intake between

238 squads were observed, large differences were apparent when expressed relative to  
239 BM. Indeed, higher CHO intakes in the U13/14 squads ( $6\pm 1.2 \text{ g}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ ) compared  
240 with both the U15/16s ( $4.7\pm 1.4 \text{ g}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ ) and U18s ( $3.2\pm 1.3 \text{ g}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$ ) were  
241 found. Carbohydrate requirements for adult athletes are an evolving topic within  
242 sports nutrition and there is debate within the literature of the optimal approach.  
243 Currently, soccer players are recommended to consume 6-10  $\text{g}\cdot\text{kg}^{-1}\cdot\text{day}^{-1}$  to support  
244 training and match demands (Burke *et al.*, 2006). Conversely, recent evidence has  
245 suggested that athletes (albeit adult populations) may benefit from strategically  
246 training with lower CHO availability during carefully chosen sessions (through  
247 manipulation of CHO intake and/or timing of training) to enhance training adaptations  
248 (i.e. increased mitochondrial biogenesis) (Bartlett *et al.*, 2013; 2015). Given the  
249 obvious developmental goals of youth soccer players and the low CHO intakes  
250 reported here and previously (Ruiz *et al.*, 2007), these data suggest that youth soccer  
251 players are likely under consuming daily CHO and do not meet current daily targets.  
252 **However, given that these guidelines are for adult populations and there are currently**  
253 **no available CHO guidelines for elite youth athletes, further research is required.**

254 Distribution of CHO intake showed a typically lower intake at breakfast, particularly  
255 for the U18s, who would have a protein (e.g. eggs) based breakfast in comparison to  
256 the schoolboys (U13/14s and U15/U16s), who typically had cereal/toast. In the two  
257 schoolboy squads, bread and cereal were the most common CHO choices, similar to  
258 the findings of Iglesias-Gutierrez *et al.* (2012). These CHO choices were often chosen  
259 at breakfast (cereal), lunch (sandwiches) and snacks (toast). In contrast, the U18s  
260 would have cooked meals at breakfast and lunch, therefore not relying on a school /  
261 homemade meal.

262 In relation to protein, marked differences in the total absolute daily intake were  
263 observed between squads where the U18s were higher than the U13/14s and U15/16s  
264 ( $142\pm 24$  vs.  $97\pm 21$  vs.  $96\pm 24$  g, respectively). However, when this value was  
265 standardised for BM, the U13/14s reported higher values than the U15/16s and U18s  
266 ( $2.2\pm 0.4$  vs.  $1.6\pm 0.3$  vs.  $2.0\pm 0.3$  g·kg<sup>-1</sup>, respectively) (Table 3). Such absolute and  
267 relative values are comparable to previous findings in similar populations (Boisseau *et al.*  
268 *al.*, 2002; Ruiz *et al.*, 2007; Russell & Pennock, 2011; Briggs *et al.*, 2015) and are also  
269 considerably higher than current national dietary reference values of 0.8 g·kg<sup>-1</sup>·day<sup>-1</sup>  
270 (Department of Health, 1991). The most popular source of protein for all ages was  
271 poultry while eggs were only a main choice for the U18s. Similar to the CHO choices,  
272 this is likely a reflection of the U18s being provided with a cooked breakfast daily at  
273 the academy whereas the younger squads tended to consume cereal based breakfasts  
274 at home. To the authors' knowledge, only one research group has assessed the protein  
275 requirements of adolescent soccer players (Boisseau *et al.*, 2002 & 2007), using a  
276 nitrogen balance methodology. Results demonstrated that protein requirements of  
277 players aged 13-15 years range between 1.4-1.6 g·kg<sup>-1</sup>·day<sup>-1</sup> (Boisseau *et al.*, 2002 &  
278 2007), which is similar to current guidelines for adult athletes (1.3–1.8 g·kg<sup>-1</sup>·day<sup>-1</sup>)  
279 (Phillips and Van Loon, 2014). Therefore, in contrast to CHO, it appears that elite  
280 youth soccer players are successful in achieving daily protein requirements.

281 The distribution of daily protein intake may be a more important aspect of an athlete's  
282 nutritional strategy than the total daily intake. Recent data has highlighted that  
283 distorted protein intake distribution across meals (skewed to higher intake at dinner)  
284 in an adult population results in reduced MPS stimulation in comparison to a stable  
285 protein intake (~30 g) at each main meal (breakfast, lunch and dinner) even when total  
286 absolute intake is matched (Mamerow *et al.*, 2014). The distribution of protein intake

287 at different meals was skewed for all squads in a hierarchical order of  
288 dinner>lunch>breakfast (Figure 1). In relation to optimal absolute protein dose,  
289 Witard *et al.* (2013) has previously reported that a single meal of  $\geq 20$ g high quality  
290 fast-digesting protein is necessary to induce maximal rates of MPS. Therefore, it  
291 could be suggested that some players were under-consuming protein at specific meal  
292 times. For example, the U13/14s and U15/16s consumed  $17 \pm 5$  g and  $15 \pm 4$  g,  
293 respectively, at breakfast in comparison to the U18s who consumed  $25 \pm 5$  g.  
294 Conversely, Murphy *et al.* (2014) recently suggested that a protein content of 0.25-0.3  
295  $\text{g} \cdot \text{kg}^{-1}$  BM per meal, that has high leucine content and is rapidly digestible, can  
296 achieve optimal MPS. Therefore, all squads would be achieving that value at each  
297 meal and consequently, the finding of  $< 20$  g absolute doses at certain meals may be  
298 inconsequential. However, a caveat to this paper is that the sources of habitual protein  
299 intakes for some squads would likely result in sub-optimal leucine contents. For  
300 example, whereas the U18s consume a protein based breakfast (i.e. eggs), the U13/14s  
301 and U15/16s intake of protein at breakfast was largely derived from adding milk to a  
302 predominantly CHO based breakfast (e.g. cereals, bread). Such pattern of breakfast  
303 choices in these squads is also in accordance with breakfast choices of children from  
304 the general population (Alexy *et al.*, 2010). Therefore, the schoolboys have not yet  
305 adopted a more sports specific diet. Similar to breakfast, the U18s have a significantly  
306 higher absolute protein intake at lunch in comparison to their younger counterparts  
307 ( $46 \pm 11$  vs.  $27 \pm 7$  vs  $29 \pm 9$  g, respectively), but CHO intake was similar across all  
308 squads for lunch and dinner (Figure 1).

309 Potential reasons for this difference in macronutrient intake and distribution between  
310 squads is likely related to the fact that the U18s are full-time soccer players and it is  
311 mandatory for players to consume breakfast and lunch at the academy on days they

312 attend (5/6 days·week<sup>-1</sup>). Consequently, the club has greater control over the food and  
313 beverages the U18s can choose from. In contrast, the schoolboys will have meals  
314 provided by the school they attend or packed lunches from home, so the influence of  
315 the club is considerably reduced. When youth players are promoted to full-time U18  
316 squad status, muscle hypertrophy is a key training goal (Milsom et al., 2015), which  
317 may result in players being encouraged to increase protein consumption to support  
318 resistance-training hypertrophy programmes (Phillips et al., 2014).

319 Distribution of snacks differed between squads (Table 2) and it would appear that this  
320 is consequence of differing training times between squads. The fulltime U18s trained  
321 in the morning (~10.30am) and only consumed 6% of their snacks during this period.  
322 In comparison, the school boy squads habitually train in the evening (~5pm) and  
323 consumed ~25% of their snacks during the morning period. This disparity of snack  
324 distribution across squads in the morning period may simply be due to the U18s being  
325 out training and are therefore restricted in what they can consume.

326 A limitation of the current study is the use of food dairies to analyze nutritional habits,  
327 and indeed, previous research has shown a potential under-reporting effect of up to  
328 20% (Burke *et al.*, 2001). However, even when accounting for potential under-  
329 reporting effects, it would appear that the current populations would still be under-  
330 fueling for performance in accordance with current literature (Burke *et al.*, 2006). To  
331 address this hypothesis, future research should accurately quantify the energy  
332 expenditure within elite youth soccer players through a variety of techniques such as  
333 doubly labeled water and accurate monitoring of training load through GPS  
334 technology. Additionally, the sample population for the present study was taken from  
335 a single EPL academy, and therefore may not be truly representative of elite players  
336 based at other clubs.



337 In conclusion, we provide novel data by simultaneously reporting both the total and  
338 daily distribution of macronutrient intakes in elite youth soccer players of differing  
339 ages. In agreement with previous authors, we report that soccer players are not  
340 meeting current CHO guidelines (especially U18s) though daily protein targets are  
341 readily achieved. However, we also report a skewed daily macronutrient distribution  
342 in all ages, an effect that was particularly evident for daily protein targets. In this  
343 regard, the smallest protein intakes were typically reported at breakfast and snacks  
344 whereas the largest intakes were reported in the evening meal. Given the requirement  
345 for both optimal energy availability and protein intake to support muscle hypertrophy,  
346 our data have important practical implications and suggest that key dietary goals for  
347 elite youth players should focus on both total daily macronutrient intake and optimal  
348 daily distribution patterns.

#### 349 **Acknowledgments**

350 All authors contributed to the design of the study; RN collected and analyzed all data;  
351 RN, JA, IGD, JPM, & EM drafted the manuscript; All authors critically revised the  
352 manuscript; All authors approved the final manuscript for publication. There are no  
353 conflicts of interest to disclose.

354

355

356

357

358

359

360

361

362

363

364

365

366

367

**368 References**

369 Alexy, U., Wicher, M., & Kersting, M. (2010). Breakfast trends in children and  
370 adolescents: frequency and quality. *Public Health Nutrition, 13(11)*, 1795–1802.

371 Areta, J. L., Burke, L. M., Ross, M. L., Camera, D. M., West, D. M., Broad, E. M.,  
372 Jeacocke, N. A., Moore, D. R., Stellingwerff, T., Phillips, S. M., Hawley, J. A., &  
373 Coffey, V. G. 2013. Timing and distribution of protein ingestion during prolonged  
374 recovery from resistance exercise alters myofibrillar protein synthesis. *The Journal of*  
375 *physiology, 591(9)*, 2319–31.

376 Bartlett, J. D., Hawley, J. A., & Morton, J. P. (2015). Carbohydrate availability and  
377 exercise training adaptation: Too much of a good thing? *European Journal of Sport*  
378 *Science, 15 (1)*, 3–12.

- 379 Bartlett, J. D., Louhelainen, J., Iqbal, Z., Cochran, A. J., Gibala, M. J., Gregson, W.,  
380 Close, G. L., Drust, B., and Morton, J. P. (2013). Reduced carbohydrate availability  
381 enhances exercise-induced p53 signaling in human skeletal muscle : implications for  
382 mitochondrial biogenesis. *American Journal of Physiological : Regulatory,*  
383 *Integrative and Compaative Physiology, 304 (6), 450-458.*
- 384 Boisseau, N., Le Creff, C., Loyens, M., & Poortmans, J. R. (2002). Protein intake and  
385 nitrogen balance in male non-active adolescents and soccer players. *European Journal*  
386 *of Applied Physiology, 88(3), 288–293.*
- 387 Boisseau, N., Vermorel, M., Rance, M., Duché, P., & Patureau-Mirand, P. (2007).  
388 Protein requirements in male adolescent soccer players. *European Journal of Applied*  
389 *Physiology, 100(1), 27–33.*
- 390 Briggs, M., Cockburn, E., Rumbold, P., Rae, G., Stevenson, E., & Russell, M. (2015).  
391 Assessment of Energy Intake and Energy Expenditure of Male Adolescent Academy-  
392 Level Soccer Players during a Competitive Week. *Nutrients, 7(10), 8392–8401.*
- 393 Burke, L.M., Cox, G. R., Cummings, N. K., & Desbrow, D. (2001). Guidelines for  
394 daily carbohydrate intake: do athletes achieve them? *Sports Medicine, 31(4), 267–299.*
- 395 Burke, L. M., Loucks, A. B., & Broad, N. (2006). Energy and carbohydrate for  
396 training and recovery. *Journal of Sports Science, 24(7), 675-685.*
- 397 Deakin, V. (2000). Measuring nutritional status of athletes: Clinical and research  
398 perspectives. In: *Clinical Sports Nutrition*. Burke, L. and Deakin, V. eds. Sydney,  
399 Australia: McCraw-Hill, 2000. Pp. 30-68.

- 400 Department of Health. (1991). Report on Health and Social Subjects: 41. *Dietary*  
401 *Reference Values for Food Energy and Nutrients for the United Kingdom*. Her  
402 Majesty's Stationary Office: Norwich.
- 403 Garaulet, M., & Gómez-Abellán, P. (2014). Timing of food intake and obesity: a  
404 novel association. *Physiology & Behavior*, *134*, 44–50.
- 405 Goedecke, J., White, N., Chicktay, W., Mahomed, H., Durandt, J., & Lambert, M.  
406 (2013). The Effect of Carbohydrate Ingestion on Performance during a Simulated  
407 Soccer Match. *Nutrients*, *5*(12), 5193–5204.
- 408 Gleeson, M., & Bishop, N.C. (2000). Elite athlete immunology: importance of  
409 nutrition. *International Journal Sports Medicine*, *21* (1), S44-50.
- 410 Gunnarsson, T. P., Bendiksen, M., Bischoff, R., Christensen, P. M., Lesivig, B.,  
411 Madsen, K., Stephens, F., Greenhaff, P., Krstrup, P., & Bangsbo, J. (2013). Effect of  
412 whey protein- and carbohydrate-enriched diet on glycogen resynthesis during the first  
413 48 h after a soccer game. *Scandinavian Journal of Medicine & Science in Sports*,  
414 *23*(4), 508–515.
- 415 Iglesias-Gutiérrez, E., García-Rovés, P. M., Rodríguez, C., Braga, S., García-Zapico,  
416 P., & Patterson, Á. M. (2005). Food Habits and Nutritional Status Assessment of  
417 Adolescent Soccer Players. A Necessary and Accurate Approach. *Canadian Journal*  
418 *of Applied Physiology*, *30*(1), 18–32.
- 419 Iglesias-Gutiérrez, E., García, Á., García-Zapico, P., Pérez-Landaluce, J., Patterson,  
420 Á. M., & García-Rovés, P. M. (2012). Is there a relationship between the playing  
421 position of soccer players and their food and macronutrient intake? *Applied*  
422 *Physiology, Nutrition & Metabolism*, *37*(2), 225–232.

- 423 Jeukendrup, A. (2014). A Step Towards Personalized Sports Nutrition: Carbohydrate  
424 Intake During Exercise. *Sports Medicine*, 44(1), 25–33.
- 425 Johnston, J. D. (2014). Physiological links between circadian rhythms, metabolism  
426 and nutrition. *Experimental Physiology*, 99(9), 1133–1137.
- 427 Leblanc, J. C., Le Gall, F., Grandjean, V., & Verger, P. (2002). Nutritional Intake of  
428 French Soccer Players at the Clairefontaine Training Center. *International Journal of*  
429 *Sport Nutrition & Exercise Metabolism*, 12(3), 268.
- 430 Leidy, H. J., Clifton, P. M., Astrup, A., Wycherley, T. P., Westerterp-Plantenga, M.  
431 S., Luscombe-Marsh, N. D., & Mattes, R. D. (2015). The role of protein in weight loss  
432 and maintenance. *American Journal of Clinical Nutrition*, 101(6), 1320S–1329.
- 433 Magkos, F., & Yannakoulia, M. (2003). Methodology of dietary assessment in  
434 athletes: concepts and pitfalls. *Current Opinion in Clinical Nutrition & Metabolic*  
435 *Care*, 6(5), 539-549.
- 436 Mamerow, M. M., Mettler, J. a, English, K. L., Casperson, S. L., Arentson-lantz, E.,  
437 Sheffield-Moore, M., & Paddon-jones, D. (2014). Dietary Protein Distribution  
438 Positively Influences 24-h Muscle Protein Synthesis in Healthy Adults. *The Journal of*  
439 *Nutrition*, 144 (6), 876–880.
- 440 Mori, H. (2014). Effect of timing of protein and carbohydrate intake after resistance  
441 exercise on nitrogen balance in trained and untrained young men. *Journal of*  
442 *Physiological Anthropology*, 33(1), 24.
- 443 Milsom, J., Naughton, R., O'Boyle, A., Iqbal, Z., Morgans, R., Drust, B., & Morton,  
444 J.P. (2015). Body composition assessment of English Premier League soccer players:

445 a comparative DXA analysis of first team, U21 and U18 squads. *Journal of Sports*  
446 *Science*, 16, 1-8.

447 Murphy, C. H., Hector, A. J., & Phillips, S. M. (2014). Considerations for protein  
448 intake in managing weight loss in athletes. *European Journal of Sport Science*, 15 (1),  
449 21–28.

450 Phillips, S. M. (2014). A brief review of critical processes in exercise-induced  
451 muscular hypertrophy. *Sports Medicine*, 44, S71-77.

452 Phillips, S. M., & Van Loon, L. J. C. (2011). Dietary protein for athletes: From  
453 requirements to optimum adaptation. *Journal of Sports Sciences*, 29(1), S29–S38.

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

456 Russell, M., & Pennock, A. (2011). Dietary analysis of young professional soccer  
457 players for 1 week during the competitive season. *Journal of Strength and*  
458 *Conditioning Research / National Strength & Conditioning Association*, 25(7), 1816–  
459 1823.

460 Wrigley, R., Drust, B., Stratton, G., Scott, M., & Gregson, W. (2012). Quantification  
461 of the typical weekly in-season training load in elite junior soccer players. *Journal of*  
462 *Sports Sciences*, 30(15), 1573–1580.

463 Zehnder, M., Rico-Sanz, J., Kuhne, G., & Boutellier, U. (2001). Resynthesis of  
464 muscle glycogen after soccer specific performance examined by <sup>13</sup>C-magnetic  
465 resonance spectroscopy in elite players. *European Journal of Applied Physiology*,  
466 84(5), 443–447.

467

468

469

470

471

472

473

474

475

476

477 **Table 1.** A comparison of age, body mass, height, BMI, soccer and non-soccer  
478 training between elite youth soccer players from an EPL academy from the U13/14s,  
479 U15/16s and U18s squads. Training data adapted from Brownlee *et al.* (Unpublished  
480 data).

Squad	Age (years)	Body Mass (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	Soccer Training (mins)	Non-Soccer Training (mins)
U13/14s	12.7 ± 0.6	44.7 ± 7.2	157.8 ± 11.0	17.9 ± 1.3	436 ± 29	33 ± 28
U15/16s	14.4 ± 0.5	60.4 ± 8.1	173.1 ± 7.8	20.1 ± 1.5	212 ± 57	81 ± 39
U18s	16.4 ± 0.5	70.6 ± 7.6	180.1 ± 7.3	21.7 ± 0.9	224 ± 38	89 ± 21

481 Values are mean  $\pm$  SD.

482

483

484

485

486

487

488

489

490

491

492 **Table 2.** A breakdown of frequency of snack consumption for all squads.

<b>Time Point</b>	<b>Percentage of snacks consumed within Time Point (%)</b>		
	<b>U13/14s</b>	<b>U15/16s</b>	<b>U18s</b>
<b>Morning Snack</b> (Between Breakfast & Lunch)	24	25	6
<b>Afternoon Snack</b> (Between Lunch & Dinner)	40	49	59
<b>Late Snack</b> (After Dinner)	36	26	35

493

494

495



496

497

498

499

500

501

502

503

504

505

506 **Table 3.** A comparison of daily energy and macronutrient intake between elite youth  
 507 soccer players from an EPL academy from the U13/14s, U15/16s and U18s squads  
 508 expressed as absolute and relative.

	U13/14s	U15/16s	U18s
<b>Absolute Energy (kcal)</b>	1903 ± 432.4	1926.7 ± 317.2	1958.2 ± 389.5
<b>Relative Energy (kcal·kg<sup>-1</sup>)</b>	43.1 ± 10.3 <sup>a</sup>	32.6 ± 7.9	28.1 ± 6.8
<b>Absolute CHO (g)</b>	266.3 ± 58.4	275.1 ± 61.9	223.7 ± 79.9
<b>Relative CHO (g·kg<sup>-1</sup>)</b>	6.0 ± 1.2 <sup>a</sup>	4.7 ± 1.4 <sup>b</sup>	3.2 ± 1.3
<b>Absolute Protein (g)</b>	97.3 ± 21.0	96.1 ± 13.7	142.6 ± 23.6 <sup>c</sup>
<b>Relative Protein (g·kg<sup>-1</sup>)</b>	2.2 ± 0.5	1.6 ± 0.3 <sup>d</sup>	2.0 ± 0.3
<b>Absolute Fat (g)</b>	56.1 ± 17.5	55.2 ± 10.6	60.0 ± 14.7

	<b>Relative Fat (g·kg<sup>-1</sup>)</b>	1.3 ± 0.5 <sup>a</sup>	0.9 ± 0.3	0.9 ± 0.3
--	---	------------------------	-----------	-----------

509  
510 <sup>a</sup> Denotes significant difference from both U15/16s and U18s. <sup>b</sup> Denotes significant difference  
511 from U18s. <sup>c</sup> Denotes significant difference from both U13/14s and U15/16s. <sup>d</sup> Denotes  
512 significant difference from both U13/14s and U18s. Values are mean ± SD.

513

514

515

516

517

518

519 **Figure 1.** – Comparison of total and relative CHO and protein intake for each squad  
520 across different meals. White bars represent U13/14s, grey bars represent U15/16s and  
521 black bars represent U18s. All values are mean ± SD. <sup>a</sup> Denotes significant difference  
522 from lunch, dinner and snacks. <sup>b</sup> Denotes significant difference from both lunch and  
523 snacks. <sup>c</sup> Denotes significant difference from all meals. <sup>d</sup> Denotes significant  
524 difference from both lunch and dinner. <sup>e</sup> Denotes significant difference from lunch. #  
525 Denotes significant difference from U18s. <sup>^</sup> Denotes significant difference from  
526 U13/14s and U15/16s. \* Denotes significant difference from U15/16s and U18s.

527

528

529

530

531

532

533

534

535

536

537

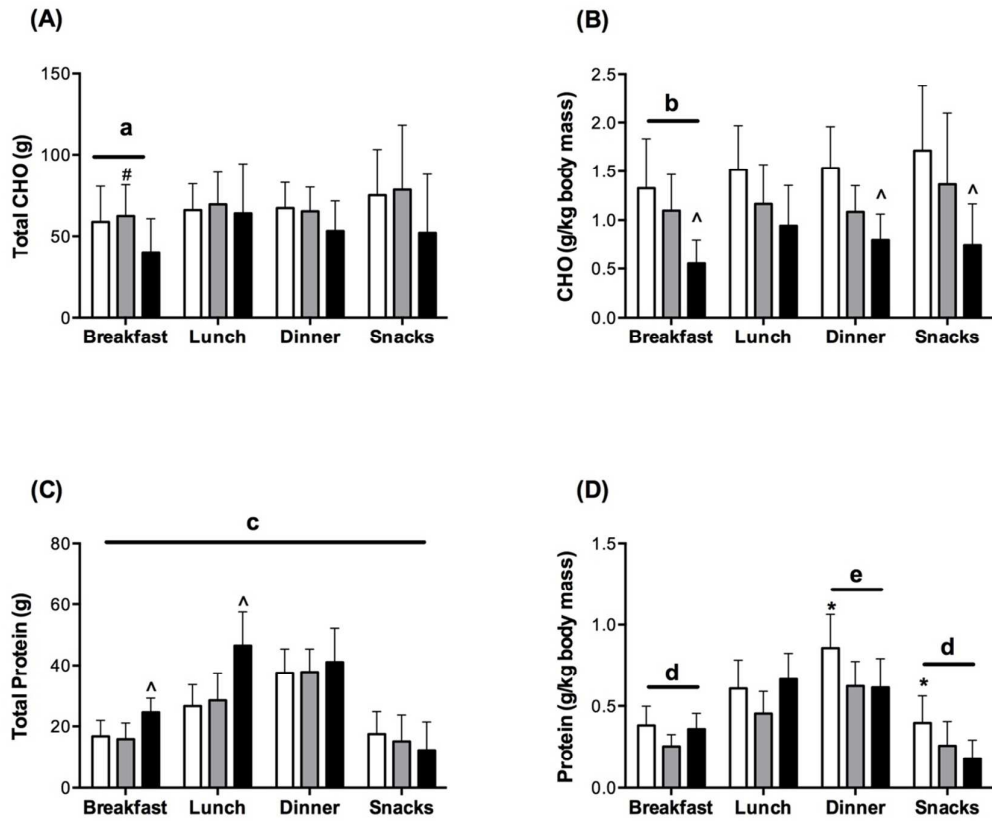
538

539

540 **Figure 1**

For Peer Review

□ U13-U14    ■ U15-U16    ■ U18



541

542

Review

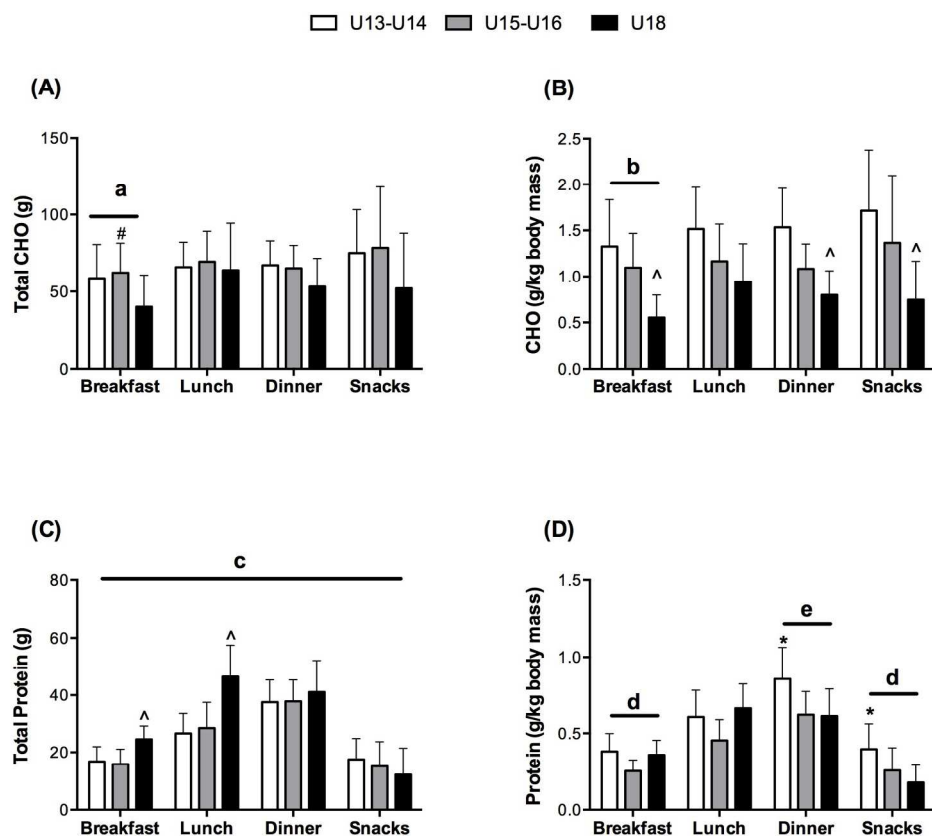


Figure 1. – Comparison of total and relative CHO and protein intake for each squad across different meals. White bars represent U13/14s, grey bars represent U15/16s and black bars represent U18s. All values are mean ± SD. a Denotes significant difference from lunch, dinner and snacks. b Denotes significant difference from both lunch and snacks. c Denotes significant difference from all meals. d Denotes significant difference from both lunch and dinner. e Denotes significant difference from lunch. Denotes significant difference from U18s. ^ Denotes significant difference from U13/14s and U15/16s. \* Denotes significant difference from U15/16s and U18s.

184x159mm (300 x 300 DPI)

Dear Editor

We thank the reviewer for their comments and have re-drafted our manuscript to address their concerns;

- 1) Please find the manuscript formatted for submission to the IJSNEM – we apologize for this original oversight.
- 2) Word count is now addressed on our cover page – 3063.
- 3) We have re-formatted our tables and graphs in our manuscript now contains 2 tables and 1 figure which contains 4 sub-figures, meeting the IJSNEM submission guidelines.

We believe this manuscript is now fit for submission and we hope you consider our manuscript for publication in the *International Journal of Sports Nutrition and Exercise Metabolism*.

Kind Regards

Robert Naughton

Dear Prof. Maughen

We would like to thank you for sending our manuscript to review and considering it for publication in the *International Journal of Sports Nutrition and Exercise Metabolism*. We thank the Reviewers for taking the time to review our manuscript and for providing us with excellent feedback. We would like to respond to their comments below;

**Response to Reviewer One**

The authors would like to sincerely thank Reviewer One for their kind feedback and recommendations for our manuscript. Their comments are extremely constructive and will certainly help improve our manuscript for potential publication.

Below we will answer each of their comments.

**Comment 1** – Reference to adaptation

On reflection the authors whole-heartedly agree with the Reviewer and have removed the reference to adaptation from the title.

**Comment 2** – Line 174 - Sentences does not make sense.

The authors thank the reviewer for highlighting this point, the amendment has been made.

**Comment 3** – Line 249 - It is not clear who you are referring to with the protein intake numbers.

The authors thank the reviewer for highlighting this point, the amendment has been made.

**Response to Reviewer Two**

The authors would like to sincerely thank Reviewer Two for their kind feedback, thorough comments and excellent recommendations for our manuscript. Their detailed review has helped us to improve this manuscript for potential publication.

Below we will answer each of their comments.

**Comment 1 – Title**

On reflection the authors whole-heartedly agree with the Reviewer and have removed the reference to adaptation from the title.

**Comment 2 – Introduction**

The authors agree that displaying the dietary intake for training days vs rest days would certainly be of interest, however within the food diaries these days were not actually reported by participants and some day this data is missing. From this data we have 2 squads reporting 2 rests days and another reporting 1, subsequently we feel we do not have a complete enough data set to accurately quantify comparisons.

**Comment 3 – Methods**

The authors thank Reviewer Two for their great suggestion and in response we have now gone through each individual food diary to record the timings of when each player consumed a snack (if any). This information is displayed in a new table 2, and discussed on page 13 where relevant, we hope this helps to clarify the timings of the snacks and meets the expectations of the Reviewer.

Regarding the second point, the authors collected the data during a 7-day period of typical training (data displayed in table 1) where there was no competitive match. The authors have now further clarified on page 6, line 123-124.

**Comment 4 – Results**

The reviewer makes an excellent point, unfortunately, due to insufficient coaching reports / data we cannot reported the training distribution. We have therefore included data which represents typical training loads from a separate study conducted on these age groups by Brownlee *et al.* (Unpublished data). Additionally, in response to comment 1 we have removed the reference to adaptation from our title.



**Comment 5 – Discussion**

The authors thank the reviewer for highlighting this point, the amendment has been made. The authors completely agree with the Reviewer regarding the CHO requirements of youth athletes being unknown and have added this into our manuscript.

**Comment 6 – Figures and Tables**

The authors completely appreciate the Reviewers recommendation; however, the authors would like to keep the y axis suitable to the data displayed. Potentially by making the y axis consistent the reader may struggle to fully appreciate the difference between meals and teams – namely for protein.

For Peer Review