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Energy Intake and Expenditure of Professional Soccer Players of the English Premier League: Evidence of Carbohydrate Periodization.

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2 **Energy intake and expenditure of professional soccer**
3 **players of the English Premier League: evidence of**
4 **carbohydrate periodization**

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52 **Running head:** Energy intake and expenditure in soccer
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83 Abstract

84 In an attempt to better identify and inform the energy
85 requirements of elite soccer players, we quantified the energy
86 expenditure (EE) of players from the English Premier League
87 (n=6) via the doubly labeled water method (DLW) over a 7-day
88 in-season period. Energy intake (EI) was also assessed using
89 food diaries, supported by the remote food photographic
90 method and 24 h recalls. The 7-day period consisted of 5
91 training days (TD) and 2 match days (MD). Although mean
92 daily EI (3186 ± 367 kcals) was not different from ($P>0.05$)
93 daily EE (3566 ± 585 kcals), EI was greater ($P<0.05$) on MD
94 (3789 ± 532 kcal; 61.1 ± 11.4 kcal.kg⁻¹ LBM) compared with
95 TD (2956 ± 374 kcal; 45.2 ± 9.3 kcal.kg⁻¹ LBM, respectively).
96 Differences in EI were reflective of greater ($P<0.05$) daily
97 CHO intake on MD (6.4 ± 2.2 g.kg⁻¹) compared with TD ($4.2 \pm$
98 1.4 g.kg⁻¹). Exogenous CHO intake was also different ($P<0.01$)
99 during training sessions (3.1 ± 4.4 g.h⁻¹) versus matches ($32.3 \pm$
100 21.9 g.h⁻¹). In contrast, daily protein (205 ± 30 g, $P=0.29$) and
101 fat intake (101 ± 20 g, $P=0.16$) did not display any evidence of
102 daily periodization. Although players readily achieve current
103 guidelines for daily protein and fat intake, data suggest that
104 CHO intake on the day prior to and in recovery from match
105 play was not in accordance with guidelines to promote muscle
106 glycogen storage.

107 **Keywords:** glycogen, training load, soccer, GPS

108 **Introduction**

109 Despite four decades of research examining the physical
110 demands of soccer match play (Reilly & Thomas, 1976; Bush
111 et al., 2015; Russell et al., 2016), the quantification of the
112 customary training loads completed by elite professional soccer
113 players have only recently been examined (Anderson et al.,
114 2015; Anderson et al., 2016; Malone et al., 2015; Akenhead et
115 al., 2016). Such data suggest that absolute training loads are not
116 as high as those experienced in match play. This is the case for
117 parameters such as total distance (e.g. <7 km v ~10-13 km)
118 (Bangsbo et al., 2006), high speed running distance (e.g. <300
119 m v >900 m) (Bradley et al., 2009), sprint distance (e.g. <150
120 m v >200 m) (Di Salvo et al., 2010) and average speed (e.g.
121 <80 m/min v ~100-120 m/min) (Anderson et al. 2015). Daily
122 training load during the weekly micro-cycle also displays
123 evidence of periodization, the pattern of which appears
124 dependent on proximity to the game itself (Anderson et al.,
125 2015) as well as the number of games scheduled (Morgans et
126 al., 2014).

127 Given the apparent daily fluctuations in training load, it
128 follows that energy expenditure (EE) may vary accordingly and
129 hence, energy intake (EI) could also be adjusted to account for
130 the goals of that particular day. Indeed, the concept of “fuelling
131 for the work required” has recently been suggested as a
132 practical framework for which to apply nutritional

133 periodization strategies to endurance athletes (Impey et al.,
134 2016). Such strategies are intended to concomitantly promote
135 components of training adaptation (e.g. activation of regulatory
136 cell signaling pathways) but yet, also ensure adequate
137 carbohydrate (CHO) (and energy) availability to promote
138 competitive performance, reduce injury risk and aid recovery
139 (Burke et al., 2011; Chamari et al., 2012; Burke et al., 2006).
140 Despite such theoretical rationale, however, it is currently
141 difficult to prescribe accurate nutritional guidelines for
142 professional soccer players owing to a lack of study that has
143 provided direct assessments of energy expenditure in the
144 modern professional adult player (Ebine et al., 2002).

145

146 Therefore, the aim of the present study was to
147 simultaneously quantify EI, EE, training load and match load in
148 professional soccer players. To this end, we studied a cohort of
149 professional players from the English Premier League (EPL)
150 during a 7-day in season period in which two match days (MD)
151 and five training days (TD) were completed. Self reported EI
152 and direct measurement of EE was assessed using food diaries
153 (supported by remote food photographic method and 24 h diet
154 recalls) and the doubly labeled water (DLW) method,
155 respectively.

156

157

158 Methods**159 Participants**

160 Six male professional soccer players (who have all
161 played international standard) from an EPL first team squad
162 (mean \pm SD; age 27 ± 3 years, body mass 80.5 ± 8.7 kg, height
163 180 ± 7 cm, body fat 11.9 ± 1.2 %, fat mass 9.2 ± 1.6 kg, lean
164 mass 65.0 ± 6.7 kg) volunteered to take part in the study. All
165 players remained injury free for the duration of the study. The
166 study was conducted according to the Declaration of Helsinki
167 and was approved by the University Ethics Committee of
168 Liverpool John Moores University.

169

170 Study Design

171 Data collection was conducted during the 2015-2016
172 EPL in-season across the months of November and December.
173 Players continued with their normal in-season training that was
174 prescribed by the club's coaching staff and were available to
175 perform in two competitive games on days 2 and 5 during data
176 collection. The last competitive game where players were able
177 to take part in was 3 days prior to the commencement of data
178 collection. During data collection, game 1 kicked off at 20:05
179 hours and game 2 kicked off at 16:15 hours, both being home
180 fixtures in European and domestic league competitions,
181 respectively. The next competitive game players were due to
182 take part in was the day after the study concluded (i.e. Day 8).

183 One day before the study commenced all players underwent a
184 whole body fan beam Dual-energy X-ray absorptiometry
185 (DXA) measurement scan (Hologic QDR Series, Discovery A,
186 Bedford, MA, USA) in order to obtain body composition, in
187 accordance with the procedures described by Milsom et al.
188 (2015).

189

190 **Quantification of Training and Match Load**

191 Pitch based training sessions were monitored using
192 portable global positioning systems (GPS) units (Viper pod 2,
193 STATSports, Belfast, UK) using methods described previously
194 (Anderson et al., 2015; Anderson et al., 2016). Players' match
195 data were examined using a computerized semi-automatic
196 video match-analysis image recognition system (Prozone
197 Sports Ltd®, Leeds, UK) and were collected using the same
198 methods as Bradley et al. (2009). This system has previously
199 been independently validated to verify the capture process and
200 subsequent accuracy of the data (Di Salvo et al., 2006; Di Salvo
201 et al., 2009).

202 Variables from the training and match data that were
203 selected for analysis included duration of activity, total distance
204 covered, the average speed and distance covered inside 3
205 different speed categories that were divided into the following
206 thresholds: running (14.4-19.7 km · h⁻¹), high-speed running
207 (19.8-25.1 km · h⁻¹), and sprinting (>25.1 km · hr⁻¹).

208

209 **Measurement of Energy Expenditure Using Doubly**
210 **Labelled Water**

211 Energy expenditure was determined by using the DLW
212 method. On the day prior to start of data collection of the study,
213 between the hours of 1400 to 1600, players were weighed to
214 the nearest 0.1kg (SECA, Birmingham, UK). Baseline urine
215 samples were then provided and collected into a 35ml tube.
216 Following collection of baseline samples, players were
217 administered orally with a single bolus dose of hydrogen
218 (deuterium ^2H) and oxygen (^{18}O) stable isotopes in the form of
219 water ($^2\text{H}_2^{18}\text{O}$) before they left the training ground. Isotopes
220 were purchased from Cortecnet (Voisins-Le-Bretonneux-
221 France). The desired dose was 10% ^{18}O and 5% Deuterium and
222 was calculated according to each participants body mass
223 measured to the nearest decimal place at the start of the study,
224 using the calculation:

225

$$226 \quad ^{18}\text{O dose} = [0.65 (\text{body mass, g}) \times \text{DIE}] / \text{IE},$$

227

228 where DIE is the desired initial enrichment ($\text{DIE} = 618.923 \times$
229 $\text{body mass (kg)}^{-0.305}$) and IE is the initial enrichment (10%)
230 100,000 parts per million.

231 To ensure the whole dose was administered, the glass
232 vials were refilled with additional water which players were

233 asked to consume. The following morning (between 09:00-
234 10:00) baseline weight samples were taken (SECA,
235 Birmingham, UK). Approximately every 24-hour, when players
236 entered the training ground (or hotel on the morning of game 2)
237 they were weighed and provided a urine sample in a 35 ml
238 tube. This urine sample could not be the first sample of the day
239 after waking as this was acting as a void pass throughout the
240 study. Urine samples were stored and frozen at -80°C in
241 airtight 1.8 ml cryotube vials for later analysis.

242 For the DLW analysis, urine was encapsulated into
243 capillaries, which were then vacuum distilled (Nagy, 1983),
244 and water from the resulting distillate was used. This water was
245 analysed using a liquid water analyser (Los Gatos Research;
246 Berman et al., 2012). Samples were run alongside three
247 laboratory standards for each isotope and three International
248 standards (Standard Light Artic Precipitate, Standard Mean
249 Ocean Water and Greenland Ice Sheet Precipitation; Craig,
250 1961, Speakman, 1997) to correct delta values to parts per
251 million. Isotope enrichments were converted to EE using a two-
252 pool model equation (Schoeller et al., 1986) as modified by
253 Schoeller (1988) and assuming a food quotient of 0.85. The
254 results from the energy expenditure data are expressed as a
255 daily average from the 7-day data collection period.

256

257

258 Total Energy Intake

259 Self reported EI was assessed from 7-day food diaries
260 for all players and reported in kilocalories (kcal) and
261 kilocalories per kilogram of lean body mass ($\text{kcal}\cdot\text{kg}^{-1}$ LBM).
262 Macronutrient intakes were also analysed and reported in
263 grams (g) and grams per kilogram of body mass ($\text{g}\cdot\text{kg}^{-1}$). The
264 period of 7 days is considered to provide reasonably accurate
265 estimations of habitual energy and nutrient consumptions
266 whilst reducing variability in coding error (Braakhuis et al.,
267 2003). On the day prior to data collection, food diaries were
268 explained to players by the lead researcher and an initial dietary
269 habits questionnaire (24 h food recall) was also performed.
270 These questionnaires were used to establish habitual eating
271 patterns and subsequently allow follow up analysis of food
272 diaries. Additionally, they helped to retrieve any potential
273 information that players' may have missed on their food diary
274 input. In addition, EI was also cross referenced from the
275 remote food photographic method (RFPM) in order to have a
276 better understanding of portion size and/ or retrieve any
277 information that players' may have missed on their food diary
278 input. This type of method has been shown to accurately
279 measure the EI of free-living individuals (Martin et al., 2009).
280 To further enhance reliability, and ensure that players missed
281 no food or drink consumption, food diaries and RFPM were
282 reviewed and cross-checked using a 24-hour recall by the lead

283 researcher after one day of entries (Thompson & Subar, 2008).
284 To obtain energy and macronutrient composition, professional
285 dietary analysis software (Nutritics Ltd, Ireland) was used.

286 Throughout the duration of this study, meals were
287 consumed at the club's training ground or home ground, a
288 nearby hotel (where the players often reside on match day) or
289 alternatively, the players' own homes or restaurants / cafes. For
290 meals provided at the training ground, home ground or hotel,
291 menus are provided on a buffet style basis where the options
292 provided are dictated by the club nutritionist and catering staff.
293 Throughout the duration of the study, all meals were consumed
294 ad libitum and it was not compulsory to eat the meals provided
295 at the training / home ground or hotel. Whenever the team
296 stayed in a hotel, the club's chef would travel and oversee the
297 food preparation in order to ensure consistency of service
298 provision.

299 On days 3 and 6, players were provided with breakfast
300 and lunch at the training ground whilst on days 1 and 4 players
301 were provided with lunch and dinner at the training ground. On
302 day 2, players were provided with breakfast at the training
303 round and lunch and pre-match meal at a nearby hotel, which
304 the club uses for each home game. On day 5, players were
305 provided with breakfast and pre-match meal at the hotel. On
306 day 7, players were provided with a lunch and post training

307 snack at the training ground and an evening meal at an away
308 game hotel.

309 Breakfast options available daily included: eggs, beans,
310 toast, porridge, muesli, fruits and yoghurts. Lunch and dinner
311 had different options that included 1 x red meat option, 1 x
312 poultry option, 1 x fish option, 3-4 carbohydrate options (e.g.
313 pasta, rice, potatoes, quinoa), 2 x vegetable options alongside a
314 salad bar and snacks such as yoghurts, nuts, cereal bars and
315 condiments. During training sessions, players were provided
316 with low calorie isotonic sports drinks (Gatorade G2), water
317 and upon request, isotonic energy gels (Science in Sport GO
318 Istonic Gels). During games, players were provided with sports
319 drinks (Gatorade Sports Fuel), water and isotonic energy gels
320 (Science in Sport GO Istonic Gels). All carbohydrate provided
321 during training and matches were consumed ad libitum.

322

323 **Statistical Analysis**

324 All data are presented as the mean \pm standard deviation
325 (SD). Training load data are shown for descriptive purposes
326 only. Daily energy and macronutrient intake were analysed
327 using one-way repeated measures ANOVAs. When there was a
328 significant ($P < 0.05$) effect of “day”, Tukey post-hoc pairwise
329 comparisons were performed to identify which day differed.
330 The normal distribution of differences between data pairs was
331 verified with Shapiro-Wilk tests ($P > 0.05$ for all variables).

332 Paired Student's t tests (with statistical significance set at
333 $P < 0.05$) were then used to assess the differences between the
334 average daily EI and EE, the difference between CHO intake
335 during training and matches, the difference between EI and
336 CHO intake on match days vs. training days, and changes in
337 body mass from before to after the study period. In all the
338 analyses, the mean difference standardized by the between-
339 subject standard deviation was used as the effect size (ES). The
340 magnitude of the ES was evaluated as trivial (>0.2), small
341 (>0.2 to 0.6), moderate (>0.6 to 1.2), large (>1.2 to 2.0), very
342 large (>2.0 to 4.0), and extremely large (>4.0) (Hopkins et al.,
343 2009). The statistical analysis was carried out with R, version
344 3.3.1.

345

346 **Results**

347 **Quantification of Daily and Accumulative Weekly Load**

348 An overview of the individual daily training and match
349 load and the accumulative weekly load is presented in Tables 1
350 and 2, respectively.

351

352 **Quantification of Energy and Macronutrient Intake**

353

354 A comparison of daily energy and macronutrient intake
355 is presented in Figure 1. Daily absolute and relative EI and
356 CHO intake was significantly different across the 7-day period

357 (all $P < 0.05$). Specifically, players reported greater absolute and
358 relative EI on day 2 (i.e. match day 1) compared with days 1
359 (both $P < 0.05$ and both $ES = 1.0$, moderate) and 3 (both $P < 0.05$
360 and both $ES = 1.1$, moderate). On day 5 (i.e. match day 2),
361 players reported higher absolute and relative EI compared with
362 days 1, 3, 4 and 6 (all $P < 0.05$; ES for absolute EI equal to 1.9
363 (large), 1.9 (large), 1.8 (large), and 2.1 (very large); ES for
364 relative EI equal to 1.4, 1.5, 1.6, 1.6 (all large)). Additionally,
365 players reported higher absolute and relative EI on day 7
366 compared with day 4 (both $P < 0.05$; $ES = 0.9$ (moderate) for
367 absolute EI and 0.6 (small) for relative EI) as well as higher
368 absolute EI on day 5 compared to day 2 ($P = 0.03$; $ES = 0.9$,
369 moderate).

370

371 In relation to CHO intake, both absolute (all $P < 0.01$)
372 and relative intake (all $P < 0.01$) was greater on day 2 compared
373 to days 1 ($ES = 1.1$ and 0.9 (both moderate), respectively for
374 absolute and relative intake), 3 ($ES = 1.5$ and 1.3 (both large)
375 respectively for absolute and relative intake), 4 ($ES = 1.4$
376 (large) and 1.2 (moderate), respectively for relative and
377 absolute intake), and 6 ($ES = 1.6$ and 1.4 (both large),
378 respectively for absolute and relative intake). On day 5, both
379 absolute and relative CHO intakes were higher than days 1
380 (both $P < 0.02$; $ES = 1.5$ and 1.3 respectively for absolute and
381 relative intake, both large) and 6 (both $P < 0.02$; $ES = 1.1$ and

382 1.1 respectively for absolute and relative intake, both
383 moderate). Absolute CHO intake was also higher on day 5
384 compared to day 4 ($P=0.05$; $ES = 2.0$, large), but did not
385 achieve significance when expressed relatively ($P=0.06$).

386

387 In contrast to energy and CHO intake, there was no
388 significant difference between days in the reported absolute
389 protein ($P=0.29$), relative protein ($P=0.31$), absolute ($P=0.16$)
390 and relative fat ($P=0.16$) intake.

391

392 **Energy and Macronutrient Intake on Training vs. Match** 393 **Days**

394 EI and EI relative to LBM were also greater (both $P<0.05$; ES
395 = 2.2 (very large) and 1.7 (large), respectively for absolute and
396 relative EI) on match days (3789 ± 532 kcal; 61.1 ± 11.4
397 kcal·kg⁻¹ LBM) compared with training days (2956 ± 374 kcal;
398 45.2 ± 9.3 kcal·kg⁻¹ LBM, respectively). Additionally, CHO
399 intake and CHO intake relative to body mass were also greater
400 (both $P<0.05$; $ES = 1.8$ (large) and 4.2 (very large),
401 respectively for absolute and relative CHO, respectively, both
402 large) on match days (330 ± 98 g; 6.4 ± 2.2 g·kg⁻¹) compared
403 with training days (508 ± 152 g; 4.2 ± 1.4 g·kg⁻¹).

404

405 **Carbohydrate intake during training and games**

406 The mean quantity of CHO consumed during the two
407 competitive matches ($32.3 \pm 21.9 \text{ g}\cdot\text{h}^{-1}$; Player 1-6 data: 25.1,
408 24.8, 70.9, 29.9, 38.3 and $4.9 \text{ g}\cdot\text{h}^{-1}$, respectively) was
409 significantly higher ($P < 0.05$) than that consumed during
410 training sessions ($3.1 \pm 4.4 \text{ g}\cdot\text{h}^{-1}$; Player 1-6 data: 0, 0.3, 11, 0,
411 5.7 and $1.6 \text{ g}\cdot\text{h}^{-1}$, respectively), with an ES of 6.6 (extremely
412 large). During training, 80 and 20% of the CHO consumed was
413 provided from gels and fluid, respectively. During match play,
414 63 and 37% of the CHO consumed was provided from gels and
415 fluids, respectively.

416

417 **Energy Expenditure vs. Energy Intake**

418 There were no significant differences ($P = 0.16$; see
419 Table 3) between average daily EE ($3566 \pm 585 \text{ kcal}$) and EI
420 ($3186 \pm 367 \text{ kcal}$), although one player did exhibit markedly
421 lower self-reported EI compared with EE (see player 6).
422 Accordingly, players' body mass did not significantly change
423 ($P = 0.84$) from before ($80.4 \pm 7.9 \text{ kg}$) to after the 7-day study
424 period ($80.3 \pm 7.9 \text{ kg}$).

425

426

427 **Discussion**

428 The aim of the present study was to simultaneously
429 quantify EI, EE, training and match load across a 7-day in-
430 season period. In order to study a weekly playing schedule

431 representative of elite professional players, we studied players
432 competing in the EPL during a weekly micro-cycle consisting
433 of two match days and five training days. To our knowledge,
434 we are also the first to report direct assessments of EE (using
435 the DLW method) in an elite soccer team competing in the EPL
436 and European competitions over a 7-day period. In relation to
437 the specific players studied herein, our data suggest that elite
438 players' daily energy expenditure can range from 3047 to 4400
439 kcal per day. Additionally, players also practice elements of
440 CHO periodization such that absolute daily CHO intake and
441 exogenous CHO feeding is greater on match days compared
442 with training days.

443

444 Key parameters of the physical loading reported here is
445 similar to that previously observed by our group during a two
446 game per week micro-cycle (Anderson et al., 2015), albeit
447 where five days was present between games as opposed to the
448 two-day period studied here. Indeed, similar accumulative
449 weekly high-speed running (1322 v 1466 m, respectively) and
450 sprint (430 v 519 m, respectively) distance were observed. This
451 result was expected given that such high-intensity loading
452 patterns are largely reflective of game time as opposed to
453 training time (Anderson et al., 2016). Interestingly, the weekly
454 accumulative total distance reported here was less than that
455 observed previously (26.4 v 32.5 km), a finding likely

456 attributable to the greater frequency of training sessions
457 completed by each player during the five-day interim period
458 (Anderson et al., 2015). Such data reiterate how subtle
459 alterations to the match and training schedule affects weekly
460 loading patterns.

461

462 The mean daily EI and EE data reported here suggest
463 that elite players are capable of matching overall weekly energy
464 requirements. It is noteworthy, however, that despite no player
465 experiencing body mass loss or gain during the study period,
466 two players appeared to be under-reporting EI as evidenced by
467 a mismatch between EI versus EE data. The mean daily EE
468 (3566 ± 585 kcals) and EI (3186 ± 367 kcals) observed here
469 agrees well that previously observed in professional Japanese
470 players (3532 ± 432 and 3113 ± 581 kcal, respectively) where
471 both DLW and 7-day food diaries were also used as
472 measurement tools (Ebine et al., 2002). Although these authors
473 did not provide any data related to physical loading, the
474 similarity between studies is likely related to these researchers
475 also studying a two-game per week playing schedule where
476 consecutive games were also separated by two days.
477 Interestingly, our EE data are much lower than that reported by
478 our group for professional rugby players (5378 ± 645 kcal),
479 thereby providing further evidence that nutritional guidelines

480 for team sports should be specific to the sport and athlete in
481 question (Morehen et al., 2016)

482

483 A limitation of the DLW technique is the inability to
484 provide day-to-day EE assessments hence data are expressed as
485 mean daily EE for the 7-day data collection period.
486 Nonetheless, the players studied here appear to adopt elements
487 of CHO periodization in accordance with the upcoming
488 physical load and likely differences in day-to-day EE. For
489 example, both absolute and relative daily energy and CHO
490 intake was greater on match days (3789 ± 532 kcal and $6.4 \pm$
491 $2.2 \text{ g}\cdot\text{kg}^{-1}$, respectively) compared with training days ($2948 \pm$
492 347 kcal and $4.2 \pm 1.4 \text{ g}\cdot\text{kg}^{-1}$, respectively). Such differences in
493 daily EI also agrees with recent observations from adult
494 professional players of the Dutch league (Bettonviel et al.,
495 2016) where subtle differences were observed between match
496 days, training days and rest days (3343 ± 909 , 3216 ± 834 and
497 2662 ± 680 kcal, respectively). It is also noteworthy that we
498 observed greater energy intake on day 7 (prior to another match
499 undertaken on day 8) versus day 4 (prior to match day 2). Such
500 differences may reflect additional energy intake that is
501 consumed prior to and during travelling (i.e. snacks provided
502 on the bus) to the away game on day 8. We also observed CHO
503 ingestion was significantly lower during training sessions (3.1
504 $\pm 4.4 \text{ g}\cdot\text{min}^{-1}$) compared with matches ($32.3 \pm 21.9 \text{ g}\cdot\text{min}^{-1}$). It

505 is, of course, difficult to ascertain whether such alterations to
506 CHO fuelling patterns were a deliberate choice of the player
507 and/or a coach (sport scientist) led practice or moreover, an
508 unconscious choice.

509

510 In the context of a two game week, it is likely that
511 players did not consume adequate CHO to optimize muscle
512 glycogen storage in the day prior to and in recovery from the
513 games (Bassau et al., 2002; Krstrup et al., 2006). This point is
514 especially relevant considering the inability to fully replenish
515 muscle glycogen content in type II fibres 48 h after match play,
516 even when CHO intake is $> 8 \text{ g}\cdot\text{kg}^{-1}$ body mass per day
517 (Gunnarsson et al., 2013). In relation to match day itself, it is
518 noteworthy that four players did not meet current CHO
519 guidelines ($30\text{-}60 \text{ g}\cdot\text{h}^{-1}$) for which to optimize aspects of
520 physical (Burke et al., 2011), technical (Ali & Williams, 2009;
521 Russell et al., 2012) and cognitive (Welsh et al., 2002)
522 performance. Interestingly, CHO intake during match play was
523 highest in players 3 and 5 who also tended to be the players
524 (midfielders) with the greatest physical load on match days.
525 Positional differences may therefore contribute to habitual
526 fuelling strategies. When taken together, data suggest that
527 players may benefit from consuming greater amounts of CHO
528 in the day prior to and in recovery from match play (so as to
529 optimize muscle glycogen storage) as well as consumer greater

530 amounts of CHO during exercise to maximize the
531 aforementioned components of soccer performance.

532

533 Although we observed evidence of CHO periodization
534 during the week, players reported consistent daily protein and
535 fat intakes. Interestingly, absolute and relative daily protein
536 intakes were higher (205 ± 30 g) than that reported two decades
537 ago in British professional players (108 ± 26 g), whereas both
538 CHO and fat intake were relatively similar (Maughan, 1997).
539 Our observed daily protein intakes also agree well with those
540 reported recently (150-200 g) in adult professional players from
541 the Dutch league (Bettonviel et al., 2016). Such differences
542 between eras are potentially driven by the increased scientific
543 research and resulting athlete (and coach) awareness of the role
544 of protein in facilitating training adaptations and recovery from
545 both aerobic and strength training (Moore et al., 2014;
546 McNaughton et al., 2016).

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548 In summary, we simultaneously quantified for the first
549 time the daily physical loading, EI and EE during a weekly
550 micro-cycle of elite level soccer players from the English
551 Premier League. Although players appear capable of matching
552 daily energy requirements to EI, we also observed elements of
553 CHO periodization in that players consumed higher amounts of
554 CHO on match days versus training days. Whilst daily protein

555 intake was consistent throughout the week, absolute daily
556 protein intake was greater than previously reported in the
557 literature. Moreover, CHO intakes were below that which is
558 currently recommended for when players are completing 2
559 competitive games in close proximity to one another.

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562 **Acknowledgements**

563

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

568

569 **Author Contributions**

570 Each author contributed as follows: LA, GLC, RM, BD and
571 JPM conceived and designed the experiments. LA, PO, JM,
572 DR, AOB, JL performed sample collection. LA, PO, RJN, JM,
573 RDM, CH, JRS performed analytical measures and related data
574 analysis. LA and JPM wrote the manuscript and all authors
575 revised and critically evaluated the manuscript for important
576 intellectual content. All authors approved the final version of
577 the manuscript prior to submission and are accountable for data
578 accuracy and integrity.

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Table 1. Training and match load variables (representative of average daily data in bold and individual data from players 1-6) completed in the 7-day testing period. Running distance = distance covered between 14.4-19.8 km/h, high-speed running distance = distance covered between 19.8-25.2 km/h and sprinting distance = distance covered >25.2 km/h. Each player's position is shown in brackets. CF=Centre Forward, WD=Wide Defender, WM=Wide Midfielder, CDM=Central Defending Midfielder, CAM= Central Attacking Midfielder and CD=Central Defender.

	Day						
	1	2	3	4	5	6	7
Duration (min)	52 ± 26	97 ± 42	17 ± 29	46 ± 0	76 ± 39	8 ± 20	24 ± 0
1 (CF)	63	125	0	46	71	0	24
2 (WD)	63	125	0	46	96	0	24
3 (WM)	63	55	34	46	96	0	24
4 (CDM)	63	125	0	46	0	48	24
5 (CAM)	63	125	0	46	96	0	24
6 (CD)	0	32	68	46	96	0	24
Total Distance (m)	2865 ± 1494	9746 ± 5098	1036 ± 1758	2187 ± 355	8827 ± 4874	715 ± 1751	1061 ± 186
1 (CF)	3266	11631	0	1964	6981	0	1076
2 (WD)	2679	11798	0	2162	10302	0	1022
3 (WM)	3384	4562	1978	2727	12793	0	1092
4 (CDM)	3603	13513	0	1680	0	4290	737
5 (CAM)	4258	14730	0	2356	13153	0	1306
6 (CD)	0	2243	4240	2234	9733	0	1131
Av. Speed (m/min)	45.9 ± 23.8	100.7 ± 50.7	20.1 ± 31.2	47.8 ± 7.8	95.8 ± 49.7	14.9 ± 36.6	45.2 ± 5.0
1 (CF)	52.1	105.7	0	42.8	97.9	0	44.2
2 (WD)	44.1	109.4	0	47.5	106.8	0	42.5
3 (WM)	54.0	132.6	57.4	59.8	132.7	0	46.4
4 (CDM)	57.5	122.2	0	36.6	0	89.5	38.4
5 (CAM)	68	134.2	0	51.4	136.4	0	53.6
6 (CD)	0	0	63.4	48.8	100.9	0	46.4
Running Distance (m)	171 ± 122	1528 ± 1033	66 ± 114	91 ± 77	1483 ± 1061	67 ± 163	0
1 (CF)	186	1490	0	43	845	0	0
2 (WD)	115	1754	0	108	1646	0	0
3 (WM)	166	717	123	225	2606	0	0
4 (CDM)	184	2513	0	3	0	399	1
5 (CAM)	375	2686	0	107	2732	0	0
6 (CD)	0	6	275	57	1067	0	0
High-Speed Running Distance (m)	27 ± 25	637 ± 446	5 ± 8	24 ± 35	614 ± 421	15 ± 37	0
1 (CF)	31	739	0	8	473	0	0
2 (WD)	21	906	0	36	665	0	0
3 (WM)	4	317	12	90	1081	0	0
4 (CDM)	34	592	0	0	0	90	0
5 (CAM)	70	1270	0	8	1081	0	0
6 (CD)	0	0	17	0	386	0	0
Sprinting Distance (m)	2 ± 4	196 ± 146	0	5 ± 7	273 ± 167	0	0
1 (CF)	0	332	0	0	157	0	0
2 (WD)	0	226	0	14	325	0	0
3 (WM)	0	113	0	14	379	0	0
4 (CDM)	0	119	0	0	0	0	0
5 (CAM)	10	386	0	0	406	0	0
6 (CD)	0	0	0	0	95	0	0

Table 2. Accumulative training and match load variables (representative of average data in bold and individual data from players 1-6) completed in the 7-day testing period. Running distance = distance covered between 14.4-19.8 km/h, high-speed running distance = distance covered between 19.8-25.2 km/h and sprinting distance = distance covered >25.2 km/h. Each player's position is shown in brackets. CF=Centre Forward, WD=Wide Defender, WM=Wide Midfielder, CDM=Central Defending Midfielder, CAM= Central Attacking Midfielder and CD=Central Defender.

	Matches	Training	Total
Duration (min)	142 ± 45	178 ± 22	321 ± 33
1 (CF)	166	163	328
2 (WD)	191	163	353
3 (WM)	117	202	319
4 (CDM)	94	211	305
5 (CAM)	191	162	353
6 (CD)	96	169	266
Total Distance (m)	16677 ± 5914	9760 ± 1852	26438 ± 5408
1 (CF)	16937	7981	24918
2 (WD)	20602	7362	27963
3 (WM)	15489	11047	26536
4 (CDM)	11511	12311	23823
5 (CAM)	25792	10012	35804
6 (CD)	9733	9849	19582
Running Distance (m)	2920 ± 1403	485 ± 202	3405 ± 1501
1 (CF)	2257	307	2564
2 (WD)	3361	263	3624
3 (WM)	3182	655	3837
4 (CDM)	2400	701	3101
5 (CAM)	5253	647	5900
6 (CD)	1067	338	1405
High-Speed Running Distance (m)	1218 ± 682	104 ± 46	1322 ± 717
1 (CF)	1151	100	1251
2 (WD)	1519	108	1628
3 (WM)	1383	122	1505
4 (CDM)	592	124	716
5 (CAM)	2276	153	2429
6 (CD)	386	17	403
Sprinting Distance (m)	423 ± 269	7 ± 7	430 ± 274
1 (CF)	489	1	490
2 (WD)	552	14	566
3 (WM)	493	14	507
4 (CDM)	119	0	119
5 (CAM)	793	10	803
6 (CD)	95	0	95

Table 3. Individual differences of average daily energy intake vs. average daily energy expenditure and body mass changes from Day 0 to Day 8. Each player's position is shown in brackets. CF=Centre Forward, WD=Wide Defender, WM=Wide Midfielder, CDM=Central Defending Midfielder, CAM= Central Attacking Midfielder and CD=Central Defender.

Player	Energy Intake (kcal)	Energy Expenditure (kcal)	Body Mass Day 0 (kg)	Body Mass Day 8 (kg)
1 (CF)	2817	3047	90.1	89.2
2 (WD)	2905	3050	73.2	73.7
3 (WM)	3563	4140	71.0	71.1
4 (CDM)	3166	3179	80.1	79.1
5 (CAM)	3701	3580	78.9	78.1
6 (CB)	2961	4400	89.0	88.9
Mean ± SD	3186 ± 367	3566 ± 585	80.4 ± 7.9	80.0 ± 7.6