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51

52 **Abstract**

53

54 **Purpose:** To quantify the seasonal training load completed by professional soccer players of
55 the English Premier League. **Methods:** Thirty players were sampled (using GPS, heart rate
56 and RPE) during the daily training sessions comprising the 2011-2012 pre-season and in-
57 season period. Pre-season data were analysed across 6 x 1 week microcycles. In-season data
58 were analysed across 6 x 6 week mesocycle blocks and 3 x 1 week microcycles at start, mid
59 and end time points. Data were also analysed with respect to number of days prior to a match.
60 **Results:** Typical daily training load (i.e. total distance, high speed distance, % HRmax, s-
61 RPE) did not differ during each week of the pre-season phase. However, daily total distance
62 covered was 1304 (95% CI: 434 – 2174) m greater in the first mesocycle compared with the
63 sixth . %HRmax values were also greater (3.3 (1.3 – 5.4) %) in the third mesocycle compared
64 with the first. Furthermore, training load was lower on the day before match (MD-1)
65 compared with two (MD-2) to five (MD-5) days before match, though no difference was
66 apparent between these latter time-points. **Conclusions:** We provide the first report of
67 seasonal training load in elite soccer players and observed periodization of training load was
68 typically confined to MD-1 (regardless of mesocycle) whereas no differences were apparent
69 during MD-2 to MD-5. Future studies should evaluate whether this loading and periodization
70 is facilitative of optimal training adaptations and match day performance.

71

72 **Keywords:** soccer training; team sport; GPS; heart rate; periodization.

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76

77 **Introduction**

78

79 The evolving nature of professional soccer has led to the requirement for a scientific
80 background to training planning and structure. With this demand has followed an increase in
81 the popularisation of monitoring player activities quantitatively on a daily basis. The
82 combination of factors that can be manipulated for training planning, i.e. volume and
83 intensity, is commonly referred to in soccer as ‘training load’¹. Training load (TL) can be
84 divided into two separate sub-sections termed external and internal TL. The external load
85 refers to the specific training prescribed by coaches, whilst internal load refers to the
86 individual physiological response to the external stressor². Due to the unstructured movement
87 patterns associated with soccer training, the likelihood that players will receive TL that are
88 associated with their individual requirements is limited. Therefore this has resulted in an
89 increased demand for applied objective and subjective data in order to monitor the TL and
90 subsequent response in order to maximise performance.

91

92 In recent years, the integrated use of technology to monitor TL has grown
93 exponentially in both soccer and other sports. Initially soccer teams were limited to the use of
94 subjective scales to monitor TL, in particular the use of the rating of perceived exertion
95 (RPE) scale initially developed by Borg³. This was followed by the use of heart rate (HR)
96 telemetry which allowed practitioners to measure the cardiovascular response to a given
97 exercise session. However both of these measures only provide an indication of the internal
98 response of a player, with a lack of quantification of the external work performed to attain
99 such a response. This gap in the TL monitoring conundrum led to the development of athlete
100 tracking systems that has allowed practitioners to analyse external load in team sports.
101 Examples of such systems include semi-automated multi-camera systems, local positioning

102 systems and global positioning systems (GPS). In modern soccer, teams will typically employ
103 a combination of the above mentioned methods to quantify both the external and internal TL.
104 This growth in the amount of data available to practitioners has led to an increased amount of
105 research focusing on TL quantification using such methods.

106

107 Of the current available research literature surrounds TL quantification in soccer, the
108 body of work has focused on either individual training drills or short periods of a training
109 programme. A popular topic at present relates to the quantification of small sided games
110 (SSG) under a variety of conditions. Recent studies have used a combination of methods to
111 quantify such drills, including HR telemetry^{4,5} and GPS^{6,7,8}. Other studies have attempted to
112 quantify TL across multiple sessions. The majority of this work has been carried out during
113 the in-season phase, of which includes short training microcycles of 1-2 weeks^{1,9,10}
114 mesocycles consisting of 4-10 weeks^{11,12,13,14} and longer training blocks of 3-4 months^{15,16}.
115 Some work has also attempted to quantify the TL across the pre-season phase¹⁷ and also
116 compare the TL experienced during the pre-season and in-season phases¹⁸. However the
117 majority of these studies only provide limited information regarding the TL, using duration
118 and session-RPE without the inclusion of HR and GPS data. In addition, no study has
119 attempted to quantify TL with respect to changes between mesocycles and microcycles (both
120 overall and between player's positions) across a full competitive season. There is also
121 currently limited information relating to TL in elite soccer players (i.e. those who play in the
122 highest level professional leagues), with the majority of previous work conducted using
123 adolescent soccer players. This is an important factor as the physiology of elite soccer players
124 differs significantly from those of a lower standard¹⁹.

125

126 Due to the lack of current data available in elite soccer players, the periodization
127 practices of elite teams is currently unknown. Anecdotally, team's will often employ a
128 coaches own training philosophy based on years of coaching experience. However it is
129 unknown whether the periodization practices adopted demonstrate variation in TL that is
130 typically associated with existing periodization practices²⁰. In addition, the differences in TL
131 between playing positions has yet to be fully established in the literature, with positional
132 difference information limited to match-play data²¹.

133

134 Therefore the purpose of this study was to quantify the TL employed by an elite
135 professional soccer team across an annual season including both the pre-season and in-season
136 phases using current applied monitoring methods. The study aimed to investigate the TL
137 performed by English Premier League players as such data isn't currently available in the
138 literature.

139

140 **Methods**

141

142 **Subjects**

143

144 Thirty elite outfield soccer players belonging to a team in the English Premier League with a
145 mean (\pm SD) age, height and mass of 25 ± 5 years, 183 ± 7 cm and 80.5 ± 7.4 kg,
146 respectively, participated in this study. The participating players consisted of six central
147 defenders (CD), six wide defenders (WD), nine central midfielders (CM), six wide
148 midfielders (WM) and three strikers (ST). The study was conducted according to the
149 requirements of the Declaration of Helsinki and was approved by the University Ethics
150 Committee of Liverpool John Moores University.

151

152 Design

153

154 TL data were collected over a 45 week period during the 2011-2012 annual season from July
155 2011 until May 2012. The team used for data collection competed in four official
156 competitions across the season, including European competition, which often meant the team
157 played two matches per week. For the purposes of the present study, all the sessions carried
158 out as the main team sessions were considered. This refers to training sessions in which both
159 the starting and non-starting players trained together. Therefore several types of sessions
160 were excluded from analysis including individual training, recovery sessions, rehabilitation
161 training and additional training for non-starting players. Throughout the data collection
162 period, all players wore GPS and HR devices and provided an RPE post-training session. A
163 total of 3513 individual training observations were collected during the pre-season and in-
164 season phases, with a median of 111 training sessions per player (range = 6 – 189).
165 Goalkeepers were excluded from data analysis. A total of 210 individual observations
166 contained missing data (5.9%) due to factors outside of the researcher's control (e.g. technical
167 issues with equipment). The training content was not in any way influenced by the
168 researchers. Data collection for this study was carried out at the soccer club's outdoor
169 training pitches.

170

171 TL data were broken down into five separate categories to allow full analysis of the
172 competitive season (Figure 1). The season consisted of the pre-season (6 weeks duration) and
173 in-season (39 weeks duration) phases. The pre-season phase was separated into 6 x 1 weekly
174 blocks for analysis of TL during this phase. The in-season phase was divided into 6 x 6 week
175 blocks because such division allowed the investigation of loading patterns incorporated

176 within this training unit (frequently defined as a mesocycle). Within the in-season data, three
177 separate weekly microcycles (weeks 7, 24 and 39) consisting of the same training structure
178 were selected in order to analyse the TL at the start, middle and end of the in-season phase.
179 The microcycles selected were the only weeks available which were deemed as full training
180 weeks. These weeks consisted of one match played and four training sessions scheduled on
181 the same days prior to the match. Training data were also analysed in relation to number of
182 days away from the competitive match fixture (i.e. match day minus). In a week with only
183 one match, the team typically trained on the second day after the previous match (match day
184 (MD) minus 5; MD-5), followed by a day off and then three consecutive training sessions
185 (MD-3, MD-2 and MD-1, respectively) leading into the next match.

186

187 ****Figure 1 near here****

188

189 Methodology

190

191 The player's physical activity during each training session was monitored using portable GPS
192 technology (GPSports[®] SPI Pro X, Canberra, Australia). The device provides position,
193 velocity and distance data at 5 Hz. Each player wore the device inside a custom made vest
194 supplied by the manufacturer across the upper back between the left and right scapula. All
195 devices were activated 30-minutes before data collection to allow acquisition of satellite
196 signals as per manufacturer's instructions. Following each training session, GPS data were
197 downloaded using the respective software package (GPSports[®] Team AMS software
198 v2011.16) on a personal computer and exported for analysis. A custom-built GPS receiver
199 (GPSports[®], Canberra, Australia) and software application (GPSports SPI Realtime V R1
200 2011.16) were used to time-code the start and end periods for each training session.

201 Unpublished research from our laboratory revealed the devices to have high inter-unit
202 variability²². This research revealed high limits of agreement (LoA) values when such
203 devices were used to quantify movements around a soccer-specific track of 366.6m total
204 length for both total distance (LoA 2m to -49 m) and high velocity (> 5.5 m/s) distance (LoA
205 29m to 51m) covered. Therefore each player wore the same GPS device for each training
206 session in order to avoid this variability.

207

208 The following variables were selected for analysis: total distance covered, average
209 speed (distance covered divided by training duration), high speed distance covered (total
210 distance covered above 5.5 m/s) and training duration. Numerous variables are now available
211 with commercial GPS devices, including acceleration/deceleration efforts and the estimation
212 of metabolic power¹². Recently, Akenhead et al.²³ concluded that GPS technology may be
213 unsuitable for the measurement of instantaneous velocity during high magnitude (> 4 m/s²)
214 efforts. The estimations of metabolic power are also potentially very useful for the
215 assessment of TL. However at present no study has fully quantified the reliability/validity of
216 such measures using commercial GPS devices. Therefore it was the approach of the
217 researchers to use established variables for the analysis of TL across the season.

218

219 During each training session, all players wore a portable team-based HR receiver
220 system belt (Acentas GmbH[®], Freising, Germany). The data were transmitted to a receiver
221 connected to a portable laptop and analysed using the software package (Firstbeat Sports[®],
222 Jyväskylä, Finland) to determine the percentage of HR maximum (%HRmax). Each player's
223 maximal HR value was determined prior to data collection using the Yo-Yo intermittent
224 recovery level 2 test. Immediately following the end of each training session, players were
225 asked to provide an RPE rating. Players were prompted for their RPE individually using a

226 custom-designed application on a portable computer tablet (iPad[®], Apple Inc., California,
227 USA). The player selected their RPE rating by touching the respective score on the tablet,
228 which was then automatically saved under the player's profile. This method helped minimise
229 factors that may influence a player's RPE rating, such as peer pressure and replicating other
230 player's ratings²⁴. Each individual RPE value was multiplied by the session duration to
231 generate a session-RPE (s-RPE) value²⁵.

232

233 Statistical Analysis

234

235 Data were analysed using mixed linear modelling using the statistical software R (Version
236 3.0.1). Mixed linear modelling can be applied to repeated measures data from unbalanced
237 designs, which was the case in the present study since players differed in terms of the number
238 of training sessions they participated in²⁶. Mixed linear modelling can also cope with the
239 mixture of both fixed and random effects as well as missing data from players²⁷. In the
240 present study, time period (mesocycles, microcycles and days in relation to the match (i.e.
241 MD minus) and player's position (CD, WD, CM, WM and ST) were treated as categorical
242 fixed effects. Random effects were associated with the individual players and single training
243 sessions. A stepwise procedure was used to select the model of best fit for each analysed data
244 set among a set of candidate models, that were compared using likelihood ratio tests.
245 Significance was set at $P < 0.05$. When one or more fixed effects were statistically significant
246 in the selected model, Tukey post-hoc pairwise comparisons were performed to examine
247 contrasts between pairs of categories of the significant factor(s). The effect size (ES) statistic
248 was calculated to determine the magnitude of effects by standardising the coefficients
249 according to the appropriate between-subject standard deviation, and was assessed using the
250 following criteria: < 0.2 = trivial, $0.2-0.6$ = small effect, $0.6-1.2$ = moderate effect, $1.2-2.0$ =

251 large effect, and $> 2.0 =$ very large²⁸. 95% confidence intervals (CI) of the raw and
252 standardised contrast coefficients were also calculated. Data is represented as mean \pm SD, or,
253 for pairwise comparisons of time periods or positional roles, as contrast (95% CI).

254

255 **Results**

256

257 *Pre-season microcycle analysis*

258

259 There were no significant differences ($P > 0.05$) between the models with and without the
260 effect of microcycle for duration, total distance, average speed, high speed distance,
261 %HRmax, and s-RPE. Thus, no differences were evident between the six microcycle weeks
262 for all outcome variables. Overall, CD players reported significantly lower total distance
263 values compared to CM players (660 (366 - 594) m, ES = 0.31 (0.17 – 0.45), small) and WD
264 players (546 (227 – 865) m, ES = 0.26 (0.11 – 0.41), small) (Figure 2a). ST players also
265 reported significantly lower total distance values compared to CM players (660 (309 – 1011)
266 m, ES = 0.31 (0.15 – 0.48), small) and WD players (: 543 (171 – 915) m, ES = 0.26 (0.08 –
267 0.43), small). Similar findings were evident for average speed values, with ST players
268 reporting significantly lower values compared to CM (8.2 (4.1 – 12.3) m/min, ES = 0.69
269 (0.35 – 1.04), moderate) and WD (6.1 (1.8 – 10.4) m/min, ES = 0.52 (0.15 – 0.88), small).
270 CD players also had significantly lower values compared to CM players (6.2 (2.8 – 9.5)
271 m/min, ES = 0.52 (0.24 – 0.80), small) (Figure 2b). There were no significant differences
272 found between positions for duration, high speed distance, %HRmax and s-RPE across the
273 pre-season phase ($P > 0.05$ in all likelihood ratio tests).

274

275

276 ****Figure 2 near here****

277

278 *In-season mesocycle analysis*

279

280 Total distance values were significantly higher at the start of the annual season (weeks 7-12)
281 compared to the end (weeks 37-42; Figure 3a) (1304 (434 – 2174) m, ES = 0.84 (0.28 –
282 1.39), moderate). %HRmax values were significantly higher in weeks 19-24 compared to
283 weeks 7-12 (Figure 3b; = 3.3 (1.3 – 5.4) %, ES = 0.49 (0.19 – 0.79), small). CM players
284 covered significantly more total distance compared to: CD (577 (379 – 775) m, ES = 0.37
285 (0.24 – 0.50), small); ST (849 (594 – 1104) m, ES = 0.54 (0.38 – 0.71), small), and WM (330
286 (123 – 537) m, ES = 0.21 (0.08 – 0.34), small). CM players also had a higher average speed
287 than ST (4.5 (1.4 – 7.6) m/min, ES = 0.53 (0.17 – 0.90), small) and CD (4.0 (1.5 – 6.6)
288 m/min, ES = 0.47 (0.17 – 0.77), small). WD players reported significantly higher total
289 distance values than CD (350 (150 – 550) m, ES = 0.22 (0.10 – 0.35), small) and ST (622
290 (366 – 879) m, ES = 0.40 (0.23 – 0.56), small). Differences were also found between WM
291 and ST for total distance (519 (252 – 786) m, higher total distance for WM, ES = 0.33 (0.16 –
292 0.50), small), and between WD and CD for average speed (3.6 (1.0 – 6.2) m/min, higher
293 average speed for WD, ES = 0.42 (0.12 – 0.72), small). CD players covered significantly
294 lower high speed distance compared with all other positions (44 (16 – 72) m against CM, ES
295 = 0.34 (0.12 – 0.56), small ; 61 (24 – 99) m against ST, ES = 0.48 (0.19 – 0.77), small; 56 (27
296 – 86) m against WD, ES = 0.44 (0.21 – 0.67), small; 74 (43 – 105) m against WM, ES = 0.58
297 (0.33 – 0.82), small). ST players reported lower %HRmax values compared to: CD (11.4 (7.0
298 – 15.8) %, ES = 1.68 (1.04 – 2.33), large); WD (8.1 (3.7 – 12.4) %, ES = 1.19 (0.55 – 1.82),
299 moderate); and CM (7.2 (2.9 – 11.4) %, ES = 1.06 (0.43 – 1.68), moderate). CD reported

300 higher %HRmax compared with WM (7.4 (3.8 – 10.9) %, ES = 1.09 (0.56 – 1.61), moderate).

301 There were no significant differences found between positions for duration and s-RPE.

302

303 ****Figure 3 near here****

304

305 *In-season microcycle analysis*

306

307 %HRmax was significantly lower in week 7 compared to both week 24 (6.9 (4.6 – 9.2) %, ES

308 = 1.06 (0.71 – 1.41), moderate) and week 39 (4.5 (2.2 – 6.9) %, ES = 0.69 (0.34 – 1.05),

309 moderate) (Table 1). CM players covered higher total distance compared to CD (576 (321 –

310 831) m, ES = 0.34 (0.19 – 0.49), small) and ST (489 (175 – 803) m, ES = 0.29 (0.10 – 0.47),

311 small). ST players reported lower overall average speed values compared to CM players (7.7

312 (2.2 – 13.3) m/min, ES = 0.99 (0.28 – 1.71), moderate)). WM players covered a higher

313 amount of high-speed distance across the different microcycles compared to CD (94 (43 –

314 145) m, ES = 0.47 (0.22 – 0.73), small). CD players recorded higher %HRmax values

315 compared to both WM (8.1 (4.0 – 12.2) %, ES = 1.24 (0.61 – 1.87), large) and ST players

316 (8.0 (3.2 – 12.8) %, ES = 1.23 (0.49 – 1.96), large). There were no significant differences

317 found between positions for duration and s-RPE.

318

319 ****Table 1 near here****

320

321

322 *In-Season Match Day Minus Training Comparison*

323

324 MD-1 displayed significantly lower values compared with MD-2 for all variables with the
325 exception of high speed distance (Duration: 19 (14 – 24) min, ES = 1.06 (0.79 – 1.34),
326 moderate; Total distance: 1914 (1506 – 2322) m, ES = 1.25 (0.98 – 1.52), large; Average
327 speed: 3.9 (1.4 – 6.4) m/min, ES = 0.46 (0.17 – 0.76), small; %HRmax: 2.0 (0.7 – 3.3) %, ES
328 = 0.29 (0.11 – 0.48), small; sRPE: 145 (111 – 178) au, ES = 1.05 (0.81 – 1.29), moderate).
329 MD-1 also displayed significantly lower values compared to MD-3 for all variables
330 (Duration: 25 (19 – 31) min, ES = 1.39 (1.08 – 1.70), large; Total distance: 2260 (1805 –
331 2715) m, ES = 1.48 (1.18 – 1.77), large; Average speed: 6.5 (3.8 – 9.2) m/min, ES = 0.77
332 (0.45 – 1.09), moderate; High speed distance: 82 (37 – 126) m, ES = 0.67 (0.30 – 1.03),
333 moderate; %HRmax: 3.3 (1.9 – 4.7) %, ES = 0.49 (0.28 – 0.69), small; s_RPE: 178 (139 –
334 217) au, ES = 1.29 (1.01 – 1.58), large). MD-5 displayed higher values compared to MD-1
335 for: duration (20 (11 – 28) min, ES = 1.10 (0.61 – 1.58), moderate); total distance (2116
336 (1387 – 2845) m, ES = 1.38 (0.91 – 1.86, large); high speed distance (135 (45 – 225) m, ES =
337 1.10 (0.36 – 0.83), moderate); and s-RPE 152 (90 – 213) au, ES = 1.10 (0.66 – 1.55),
338 moderate). CD players displayed lower values for duration compared to WM (5 (2 – 8) min,
339 ES = 0.27 (0.09 – 0.45), small) and ST (7 (3 – 11) min, ES = 0.38 (0.16 – 0.60), small). WD
340 players also recorded lower values for duration compared to WM (4 (1 – 8) min, ES = 0.25
341 (0.07 – 0.42), small) and ST (6 (3 – 10) min, ES = 0.36 (0.14 – 0.58), small) across all four
342 training day types. CM players covered higher total distance compared to CD (465 (251 –
343 679) m, ES = 0.30 (0.16 – 0.44), small). CD players recorded higher %HRmax values
344 compared to WD (6.9 (2.8 – 11.0) %, ES = 1.01 (0.41 – 1.62), moderate), and ST (8.1 (3.1 –
345 13.2) %, ES = 1.20 (0.46 – 1.94), large). There were no significant differences found between
346 positions for average speed, high speed distance, and s-RPE.

347

348

****Figure 4 near here****

349

350

351

352

353 **Discussion**

354

355 The purpose of the present study was to quantify the TL employed by an elite professional
356 soccer team across an annual season that included both the pre-season and in-season phases.

357 The study revealed that TL variables demonstrated limited relevant variation across both the
358 pre-season and in-season phases. This finding was evident despite marked differences
359 between positions across each microcycle. When analysing TL in respect to number of days
360 prior to a match, it was found that TL remained similar across all days with the exception of
361 MD-1 in which the load was significantly reduced. The findings of the present study provide
362 novel data on the TL undertaken by elite English Premier League players throughout a
363 competitive season.

364

365 The emphasis during pre-season is on the rebuilding of fitness parameters following
366 the detraining that occurs during the off-season²⁹. In comparison to previous studies, the HR
367 response observed in the present study was higher than that reported by Jeong et al.¹⁸. In their
368 study based on professional Korean soccer players, the average %HRmax value across all
369 pre-season sessions was 64 ± 3 %HRmax which is significantly lower than the 70 ± 7
370 %HRmax value reported in the present study. In addition the highest s-RPE value during
371 training for the Korean players was 321 ± 23 au compared to an average of 447 ± 209 au in
372 the present study. The marked differences between the two studies may relate to the external
373 work performed by each respective team during pre-season. Manzi et al.¹⁷ reported average s-

374 RPE values of 644 ± 224 au for elite Italian soccer players during an 8 week pre-season
375 phase. Although these values are higher than those reported in our study, the likely reason for
376 the differences was the inclusion of friendly match data in the study by Manzi et al.¹⁷.
377 Therefore it appears that the TL undertaken by players in the present study may be unique to
378 the design and pre-season schedule employed.

379

380 During the in-season phase, the emphasis of training reverts to technical and tactical
381 development and the maintenance of the physical capacities developed during pre-season²⁹.
382 In the present study, we investigated the TL pattern across 6 week mesocycle blocks during
383 the in-season phase of an annual season. It was observed that the players covered more total
384 distance at the start compared to the final mesocycle of the season, with an estimated
385 difference of 1304 m between the two mesocycles. The higher distances covered at the
386 beginning of the in-season phase may be due to the coaches still having some emphasis on
387 physical conditioning as a continuation of the pre-season phase. Interestingly the %HRmax
388 response in the players was higher during the third mesocycle (weeks 19 – 24) in comparison
389 to the first mesocycle (weeks 7 – 12). This was found in spite of the players covering higher
390 total distance during the first mesocycle period. In general, CM and WD covered the highest
391 total distance with CD players displaying the lowest values. Defenders (CD and WD players)
392 were found to display higher %HRmax values during this time. Such differences between
393 positions are not uncommon in elite soccer, with the findings in the present study also
394 replicated in positional match-play data (with the exception of high speed distance)²¹.
395 Therefore it appears that there is some marked variation in TL across 6 week mesocycle
396 periods during the in-season.

397

398 In order to further analyse the TL patterns, the data were broken down further into
399 microcycle periods. It was found that %HRmax values were higher during the first
400 microcycle analysed (week 7) compared to the seasonal mid-point (week 24) and end-point
401 (week 39) microcycles. When the data were broken down further in respect to the number of
402 days prior to a match, it was found that TL was significantly reduced on MD-1 with no
403 differences observed across the remaining training days. It would appear in the present study
404 that the coaches employed similar overall TL on the majority of training days, then attempted
405 to unload on MD-1 in order to increase player readiness leading into the match. In
406 comparison to previous work, the average total distance covered was 5181m which was
407 higher than the range of values reported by Gaudino et al.¹² (3618 – 4133m). However both
408 the distances covered in the present study and that of Gaudino et al.¹² fell short in comparison
409 to those reported by Owen et al.⁹(6871m). In terms of high speed distance, the values
410 reported (average 118m) fall within the range of that of Gaudino et al.¹² (88 – 137m) across
411 different positions. The %HRmax response was higher (69%) compared to that of elite
412 Korean players¹⁸ (58%). Despite this finding, the s-RPE values were relatively low (272 au)
413 in the present study compared to that of Jeong et al.¹⁸ (365 au) and in semi-professional
414 soccer players¹⁶ (462 au). Overall it would appear that in comparison to elite soccer players,
415 the TL employed fall within the boundaries of what has been previously observed.

416

417 The limited relevant variation observed in TL across the full competitive season
418 would suggest that training in professional soccer may be highly monotonous. In accordance
419 with traditional periodization models, TL must be varied in order to elicit optimal
420 physiological adaptations and limit the native effects of fatigue³⁰. Indeed, the only noticeable
421 consistent variation in TL occurred on MD-1 in which the load was significantly reduced
422 compared to the other training days. This approach may be an attempt by the coaches to

423 unload the players to increase player readiness leading into a match. However, it is currently
424 unknown in the literature whether unloading in this way will lead to the dissipation of fatigue
425 and optimise readiness. The majority of research relating to unloading (commonly referred to
426 as tapering) relates to individual sports, in which TL is reduced over the course of 7 – 28 days
427 prior to competition³¹. Such time frames of unloading are not relevant to the competition
428 scheduling associated with soccer. Although anecdotal evidence is available relating to the
429 practices and methodologies of elite soccer coaches, little information is available in the
430 research literature relating to soccer-specific periodisation models. It may be so that
431 practitioners in elite soccer must develop their own sport-specific periodisation models with
432 minimal use of the traditional approaches described in individual sports²⁰.

433

434 **Practical Applications**

435

436 This study provides useful information relating to the TL employed by an elite English
437 Premier League team. It provides further evidence of the value of using the combination of
438 different measures of TL to fully evaluate the patterns observed across a full competitive
439 season. For coaches and practitioners, the study generates reference values for players of this
440 elite level which can be considered when planning training sessions. When conducting a large
441 scale study such as this one, it is clear that some limitations may arise from the process.
442 There were numerous true data points missing across the 45 week data collection period due
443 to several external factors beyond the researcher's control (e.g. technical issues with
444 equipment, player injuries, and player transfers). In order to combat this, we have employed
445 mixed linear modelling due to the unbalanced design, although we cannot rule out the overall
446 influence on results. The lack of available GPS competitive match data in the overall analysis
447 will obviously have a significant effect on overall 'loading' throughout a season. The present

448 study is unable to provide ‘optimal’ TL values without undertaking further research linking
449 TL to other factors, such as physiological testing and injury records. What would be even
450 more valuable to both researchers and practitioners would be to establish how these TL
451 directly impact soccer performance, but this is a complex phenomenon with a multitude of
452 factors.

453

454 **Conclusions**

455

456 In summary, this study systematically quantified the TL employed by an elite English
457 Premier League soccer team across an annual season using a combination of applied
458 monitoring methods. The data from the study revealed that the TL employed across the pre-
459 season phase displayed limited variation across each individual microcycle. There was further
460 variation shown during the in-season phase, with higher total distances covered in the early
461 stages of the competitive season and the highest HR response occurring at the mid-point of
462 the season. Positional differences were found during both pre-season and in-season phases.
463 Future research should focus on how the TL employed is directly related to performance and
464 injury in elite soccer. Furthermore, data derived from multiple teams and competitive leagues
465 would also enhance our understanding of TL in the elite setting.

466

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469 all data collection procedures

470

471 **References**

472

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547 **Figures and Tables**

548

549 Figure 1. Outline of the experimental design. Each small block represents an individual
 550 weekly period across the annual cycle. Large blocks represent 6-week mesocycle periods
 551 across the in-season phase. Minus symbol represents training session in respect to number of
 552 days prior to a competitive match. MD = match day; O = day off.

553

554 Figure 2. Training load data represented across 6 x 1 week microcycles during the pre-season
 555 phase between positions. a) total distance; b) average speed. # denotes CM sig. difference vs.
 556 CD and ST; \$ denotes WD sig. difference vs. CD and ST; ≠ denotes WD sig. difference vs.
 557 ST; CD = Central defenders; WD = Wide defenders; CM = Central midfielders; WM = Wide
 558 midfielders; ST = Strikers. Data represents average values per session in the time period
 559 selected.

560

561 Figure 3. Training load data represented across six separate 6 week mesocycle periods during
 562 the in-season phase between positions. a) total distance; b) % HRmax. * denotes weeks 7-12
 563 sig. difference vs. weeks 37-42; # denotes weeks 19-24 sig. difference vs. weeks 7-12; ¥
 564 denotes CM sig. difference vs. CD, WM and ST; \$ denotes WD sig. difference vs. CD and
 565 ST; ∑ denotes WM sig. difference vs. ST; Δ denotes CD sig. difference vs. WM; £ denotes
 566 ST sig. difference vs CD, WD and CM; CD = Central defenders; WD = Wide defenders; CM
 567 = Central midfielders; WM = Wide midfielders; ST = Strikers. Data represents average and
 568 SD values per session in the time period selected.

569

570 Figure 4. Training load data represented on training day in respect to days prior to a
 571 competitive match during the in-season phase between positions. a) duration; b) total
 572 distance; c) s-RPE. * denotes MD-2 sig. difference vs. MD-1; # denotes MD-3 sig. difference
 573 vs. MD-1; \$ denotes MD-5 sig. difference vs. MD-1; ¥ denotes CD and WD sig. difference
 574 vs. WM and ST; Δ denotes CD sig. difference vs. CM and WM; CD = Central defenders;
 575 WD = Wide defenders; CM = Central midfielders; WM = Wide midfielders; ST = Strikers.
 576 Data represents average values per session in the time period selected.

577

578

579 Table 1. Training load data represented across 3 separate one week microcycles during the in-
580 season phase between positions. * denotes week 7 sig. difference vs. week 24 and week 39. #
581 denotes CM sig. difference vs. CD and ST; Δ denotes WM sig. difference vs. CD; \$ denotes
582 CM sig. difference vs. ST; £ denotes CD sig. difference vs. WM and ST; CD = Central
583 defenders; WD = Wide defenders; CM = Central midfielders; WM = Wide midfielders; ST =
584 Strikers. Data represents average and SD values per session in the time period selected
585
586