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#### **Running More than Before?**

## The Evolution of Running Load Demands in English Premier **League Football**

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#### 26 ABSTRACT

- Purpose: The purpose of this study was to assess the running load trends (total distance (TD), high
  intensity distance (HID; >5.5ms<sup>-1</sup>) and sprint distance (SprD; >7ms<sup>-1</sup>)) in the English Premier League
  (EPL) between the 2014/15 and 2018/19 seasons using a semi-automated optical tracking system.
- 30 **Methods**: 1634 games across 5 seasons (2014/15-2018/19) were analysed for team and positional TD,
- 31 HID and SprD. All matches were tracked using TRACAB® Gen-4 HD motion cameras. Data was analysed
- 32 to identify significant team and positional differences for each metric.
- 33 **Results:** Small to moderate increases were seen in team running load for TD (*p*=0.02; ES: 0.21), HID 34 (p<0.001; ES: 0.88) and SprD (p<0.001; ES: 0.67) between 2014/15 and 2018/19. Positional analysis 35 showed significant increases in TD for all except for defensive-midfielders, attacking-midfielders and 36 wide-midfielders (p<0.001-0.009; ES: 0.14-0.36); HID for all positions excluding goalkeepers 37 (p<0.001-0.007; ES: 0.2-0.54) and SprD for all positions except for goalkeepers, central-midfielders 38 and attacking-midfielders, (p<0.001-0.020; ES: 0.19-0.39). Trivial to small differences were seen in 39 season-to-season comparisons for TD (p<0.001-0.023; ES: -0.16-0.52), HID (p<0.001 - 0.033; ES: 0.10-(0.38) and SprD (p<0.001-0.025; ES: (0.13-0.27) for both team and positional differences. 40
- 41 **Conclusion**: Small to moderate increases in team TD, HID and SprD occurred in the EPL between 42 2014/15 and 2018/19, with trivial to small changes in season-to-season variations. Actual changes in 43 running load over time appear to be dependent on playing position. Running load trends should be 44 updated regularly and practitioners need to be aware that there may be variations within their team, 45 and program accordingly.
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#### 55 Introduction

Player load monitoring is a common term used within elite football and is a consistent means of assessing the running load players perform in both training and competition (1). Running loads during competitive matches have been proposed to have become more intense, placing greater physical stress upon the modern-day footballer (2). However, the literature underpinning this extrapolation is dated, with almost 10 years since the last study in the English Premier League (EPL) (3) and may not fully represent the running load profiles of players since 2013.

62 Running load outputs in competition are commonly obtained through either optical, or more recently 63 global positioning systems. High intensity distance (HID) in the EPL increased in games between 2006-64 2013 (HID; +30%; >5.5ms<sup>-1</sup> and sprinting distance (SprD; +35%; >7ms<sup>-1</sup>; (3)). Positionally, full backs were shown to have the highest increases (HID: 35% and SprD 62%) and attackers the lowest (HID: 65 24% and SprD 36%; (4)). Therefore, consideration must be given to the evolving positional and 66 67 individual differences displayed in running load in relation to positional demands, to effectively physically prepare players for their positional requirements (4,5). Additionally, inter-individual 68 69 differences related to team playing strategies and their associated positional requirements will affect 70 the running load requirements for the player over time (5).

71 Findings from previous studies have led to the assumption that the intensity of the game will continue 72 to evolve, with predicted increases of 40% in HID by 2030 (6). Further work has highlighted the 73 potential requirement for players to possess the capacity to perform greater acceleration and 74 deceleration movements more efficiently (2). There is a lack of recent evidence surrounding running 75 load (volume and intensity) demands on players within the EPL and predictions based on the work of 76 Barnes et al., (3) must be interpreted with caution due to the age of the study and improvements in 77 optical tracking technologies (7). For these reasons, it is important to update the current information 78 available to see if there are changes in running load trends.

The aim of the present study is to provide an update on team and positional running loads of footballers in the EPL, seeing how these have evolved over the course of 5 seasons from 2014/15 to 2018/19. This will build upon the existing literature (3) and provide more insight into how the running loads of EPL football have evolved.

#### 83 <u>Methods</u>

#### 84 Participants

Running load data of 1397 players from 1872 games over a 5-season period (2014/15 to 2018/19)
were collated in the present study. Natural variation occurred in the 1397 players analysed between

87 the number of seasons played (table 2) and number of positions players played in throughout the 88 season (table 3). Due to change of optical tracking provider (from TRACAB® to Second Spectrum®) in 89 the 2019/2020 season and changes in stoppages (additional water breaks) and increased substitutions 90 due to the impact of COVID-19, data from the 2019/2020 season was excluded from the analysis. 91 Players were split by position, determined by OPTA statistics (www.optasports.com), for more 92 detailed analysis: goalkeeper (GK), centre back (CB), full back (FB), defensive midfielder (DM), centre midfielder (CM), attacking midfielder (AM), wide midfielder (WM), centre forward (CF). 27 games in 93 94 the 5-year period did not have tracking data due to technical faults. Games where the match finished 95 with less than 22 players on the pitch (238 games; due to a sending off or injury) were removed from 96 this data set. This left 1634 games for analysis.

Table 1 displays the season-by-season number of games selected for analysis, number which finished
11v11, game duration, players utilised (in matches which finished 11v11). Ethical approval for the use
of match data was obtained from the host university, in accordance with the Helsinki Declaration.

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\*\*\*insert table 1 here\*\*\*

Table 2 shows the number of players and the corresponding number of seasons they appeared inthe analysis.

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\*\*\*insert table 2 here\*\*\*

105 Table 3 shows the number of players and the number of different positions they played in.

106 \*\*\*insert table 3 here\*\*\*

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#### 108 Data Collection

109 Positional tracking data for 1634 games over 5 EPL seasons was recorded by TRACAB® Gen-4 (TRACAB; 110 ChyronHego, New York, USA). The data for TRACAB® has been shown to be valid and reliable (8,9). 111 TRACAB® Gen-4 utilises 6 semi-automated HD cameras sampling at 25Hz, installed at a height of 36m in the EPL stadiums. The dwell time (minimum effort duration) was set at 0.5s for HID running and 1s 112 113 to detect SprD efforts as per manufacturer's guidelines. Tracking data were measured throughout the full game, including any stoppages, and added time. After the games, TRACAB® delivered a physical 114 115 summary file (Excel, .csv format) to the EPL portal. Activities analysed were total distance (TD) covered by the players, absolute HID, (speed >5.5m/s) which combines high-speed running (5.5m/s – 7m/s) 116 117 and sprint (speed >7m/s) distances, and absolute SprD. These running load measurements were 118 chosen as they are frequently reported in the literature and are often monitored closely by 119 professional football clubs when analysing optical tracking data (1,10). All player data was 120 anonymised prior to analysis to ensure confidentiality.

#### 121 Statistical Analysis

Data was analysed for season-to-season changes in team and positional (GK, CB, FB, DM, CM, AM, WM, CF) running load (i.e., 2014/15 compared to 2015/16; 2015/16 compared to 2016/17 etc.). The data was processed and analysed using R software (<u>https://www.r-project.org/</u>), Rstatix and Tidyverse.

126 A one-way ANOVA (used to determine whether there is a statistically significant difference between 127 the means of >3 groups) and Tukey's range test were used to analyse statistical significance. Statistical 128 significance was set at p<0.05. The p-value was adjusted for multiple pairwise comparisons. The effect 129 size (ES) was calculated using Cohen's d to determine the relationship between the seasons evaluated. 130 The magnitudes were reported as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2) and large (1.2–2.0) 131 (11). A confidence interval of 95% (11) was used to show the difference in mean outputs between successive seasons (i.e. 2014/15 to 2015/16; 2015/16 to 2016/17 etc.) and when comparing seasons 132 133 2014/15 to 2018/19.

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#### 135 <u>Results</u>

Team and positional running load characteristics (TD, HID and SprD) for each season are reported in
Table 4. Small to moderate increases in total team TD, HID and SprD were found when comparing
season 2014/15 to 2018/19.

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\*\*\*insert table 4 here\*\*\*

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#### 142 Team Total Running Load

Team total running load for TD, HID and SprD for each season are displayed in table 5. The main
 findings here showed trivial to small changes (majority increases) from season-to-season for team
 total TD, HID and SprD.

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\*\*\*insert table 5 here\*\*\*

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#### 149 Positional Running Load

Table 6 details the positional breakdown for TD, HID and SprD running load covered season to season(metres).

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\*\*\*insert table 6 here\*\*\*

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155 On a positional level, season-to-season changes showed trivial to small changes in running load 156 outputs for all positions apart from WMs who saw no significant change between seasons (table 6). 157 The majority of season-to-season running load changes were increases. However, while CB's exhibited 158 small increases in two of the seasons, there were also two seasons during the observation period 159 where they showed trivial decreases in TD. The combination of these trivial to small increases, cause 160 a small to moderate increase in running load over the five seasons. Small increases in TD were seen for GK, CM and CF when comparing 2014/15 to 2018/19 (table 4), whilst trivial increases occurred for 161 162 CB and FB. A small decrease in TD was seen for AMs, whilst no differences were apparent for DM or 163 WM. GKs displayed no difference in HID and SprD between 2014/15 and 2018/19 seasons (table 4). 164 All other positions had significant small increases in HID (ES=0.25-0.54) and trivial (DMs) to small (CB, 165 FB, CM, AM, CF) increases in SprD between 2014/15 and 2018/19 seasons, with the largest increases seen in CBs (HID (ES=0.54) and SprD (ES=0.38)) and CFs (SprD (ES=0.39)) (table 4). 166

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### 168 Discussion

The aim of the present study was to update team and positional running load demands in the EPL and look at the evolution across five seasons from 2014/15 to 2018/19. The most recent work identifying running load demands in EPL football was completed by Barnes et al., (3), which may no longer be representative of current positional game demands. Team totals increased for TD (small), HID (moderate) and SprD (moderate) between the 2014/15 and 2018/19 seasons. On a season-to-season basis, trivial to small changes were observed in some, but not all, of the five seasons analysed when comparing to the previous season.

176 Team Running Load

177 Significant changes in TD, HID and SprD on a team level were observed between 2014/15 and 2018/19. 178 Previous literature reports increases in running load, 2006/07 to 2012/13 highlighting a 30% and 35% 179 increase in HID and SprD respectively (3). Recently, work by Nassis et al., (6), predicted an increase of 180  $\sim$ 40% in HID by 2030, however the present body of work potentially highlights this may be 181 overestimated, highlighting increases of 12% and 15% for HID and SprD, respectively. Comparisons of 182 these data sets must consider the tracking technologies utilised to quantify the running loads. 183 Previous work (3) utilising Prozone technology had a sample frequency of 10Hz, whereas the 184 technology used in this study (TRACAB) samples at 25Hz, a factor which has been shown to increase 185 the accuracy of reported measurements (12). Research has indicated differences of ~50% in SprD values when different tracking systems are utilised (7,13), potentially, explaining the over estimations 186 187 of earlier running load data sets. For this reason, regular updates of running load trends may be required as technology advances and optical tracking providers change. 188

189 Interestingly, although mean season-to-season increases were noted for metrics of TD, HID and SprD 190 these were not consistently significant, again coherent with the findings of Barnes et al., (3). It is also 191 important to note no season saw a significant increase in all 3 variables in the same season, although, 192 over a longitudinal period all three displayed a significant increase. There could be important 193 implications to our findings, where practitioners should not ignore these incremental increases, as 194 rises in running loads should prompt the need to review training prescription and recovery methods 195 to ensure players are best prepared for game demands. These incremental increases may also allow 196 players to cope better with changes in match running load, allowing them to become more 197 accustomed and prepare for such increases. This could also be important for players coming from 198 academies, with trivial to small rises seen season-to-season; the compounding of these changes may 199 see players need to increase their average running load ~15% every 5 seasons. However, the running 200 load trends for academy players is not reported in the research literature (to our knowledge) and 201 should be addressed in future research. Additionally, the increase in the number of games through 202 additions of international tournaments may require players to produce higher running loads per game 203 as well as maintain it for more games, and more frequently, across the season. This could potentially present an increased injury risk for a player, with higher demands required across a season. 204 205 Consequently, this places an increasing emphasis on appropriate training prescription to meet the 206 increased volume, frequency and density of running load alongside implementation of recovery 207 strategies around dense fixture periods.

It is possible that tactical changes to positions (e.g., more pressing / increase in number of CM in a
formation - 442 vs 532) over the years may have caused players to run differently (more or less)
season-to-season, but this is purely speculation. Increases in high velocity running load metrics, such

as HID and SprD, may be explained by evolving formational and tactical trends (14). Research suggests 211 212 football is moving towards a higher pressing (15) and more transitional game (16), with counterattacks 213 becoming a prominent way to score (17). These transitions have been shown to increase running load 214 demands (18) and could lead to increased speed of ball play. This potentially influences the managers 215 to select players who can perform at higher speeds, evolving the physical profiles of teams in the EPL, 216 consequently contributing to an increased running load profile of teams in the EPL. These outcomes 217 will be determined by a team's style of play, with trends being shown to differ among teams (19) and 218 leagues (20). In turn, a team's style of play is likely to influence the running load requirements for 219 individual positions within a team. Future work should consider the contribution of formational and 220 tactical influence on the longitudinal analysis of running loads.

#### 221 Positional Running Loads

222 Most significant positional running load changes between 2014/15 and 2018/19 showed increases 223 across five seasons (table 4); however, AMs showed a small decrease in TD, highlighting the need for 224 practitioners to observe changes at a more granular level when making decisions around training and 225 recovery. Season-to-season running load showed most of the significant changes in positions were 226 increases, however, trivial decreases were seen in 2 seasons for CBs. This highlights how positional 227 running load can fluctuate season-to-season again emphasising the importance of practitioners 228 evaluating the running load demands in their teams and players regularly. Small and trivial increases 229 were seen in 2016/17 (ES=0.23) and 2017/18 (ES=0.18) for team TD. Positionally, 2016/17 showed 230 increases in TD by GK, CB, FB and CM and in 2017/18 increases in TD for CB, DM, CM and CF. Reasons 231 for this increase and more specifically in these seasons are unclear, but the increasing trend in 232 transitional football (16) may offer a partial explanation. Logically, evolving formational and tactical 233 demands could contribute to greater distances being covered (18,21) with faster transitions meaning 234 teams will have to move more in relation to the ball and opposition. The variations in the running load 235 outputs in each season highlight the importance for practitioners to understand the need to delve 236 deeper into match data, contextualising the running demands for individual players (22). 237 Contextualising data will allow staff to design training sessions to suit their teams and individual 238 players needs around their playing style (e.g., high press / counterattacking) and individual roles within 239 the team's training and playing methodology. The variability between players and even positions, 240 highlights the need to be aware of potential fluctuations in running load requirements through time, 241 suggesting that averages over longer periods cannot be the sole information used. Rolling averages, 242 maximum and minimum running loads may provide a richer source of information in the preparation 243 for the fluctuating demands of footballers. Over a season, increases in certain running load metrics on 244 a game-by-game basis, may mean players could be under prepared to compete at certain times in the

season. Practitioners may benefit by exposing players to higher running loads during training so players are better prepared to cope with higher match running loads. Opposition teams may cause a certain position to increase HID in matches through tactical reasons (e.g. transitions; 18). Should this occur for a period of time, players may become overexposed to HID and could increase risk to posterior thigh injury (23). This would require practitioners to adapt training demands for certain individuals.

251 Interestingly, the TD reduced for CBs (2018/19 season) when there was a significant increase in HID 252 and SprD between 2016/17 and 2017/18 season. The reduced TD in the 2018/19 season may have 253 been due to a tactical response to reduce the opportunity for teams to counter by suppressing spaces 254 between the teams. Although not significant, this same pattern was seen for the CFs TD, HID and SprD 255 in the same seasons, suggesting that these may be linked to tactical responses. Previous research has 256 shown teams movements are linked with one responding to another (i.e., one goes forward, other 257 goes back; 24). Unfortunately, due to the data set used, we cannot see whether this trend was the 258 same for the 2015/16 season due to not having TRACAB® data for the 2013/14 season.

259 No significant changes in running load were observed season-to-season for WMs. Similarly, DMs 260 showed an increase in TD in one season (2017/18) and AMs in HID in one season (2016/17). This 261 suggests there may be no significant tactical changes in the roles of a WM, or any changes in tactical 262 requirements did not have a significant impact upon WM running load. Minimal changes are seen in 263 the DM and AM roles in the EPL between seasons. Whilst speculative and requires further 264 investigation, tactical changes over the years may be one explanation to why running loads have 265 changed. Alternatively, the athletic profiles of players in these positions may not have changed too 266 much over this period. Whereas increases seen in the HID and SprD between seasons for other 267 positions (and overall team values) may be due to the athletic profiles of some of the players chosen 268 to play. It is plausible that faster players might acquire greater absolute HID and SprD values due to 269 their ability to get to those speeds easier. This will be individual dependant, due to the different player 270 profiles within a team (25). Managers may believe having faster players in key positions allows them 271 to perform tactical requirements (e.g. increased speed of transitional football) which may increase 272 success in games. This may produce a "Darwinian effect" with those who possess these traits being 273 more likely to be picked for EPL teams.

#### 274 Conclusion

The present study updates previous work observing longitudinal physical running load outputs in the EPL (3,4,28). This paper adds to the work of Barnes et al., (3), by analysing season-to-season comparisons. Running load demands between 2014/15 and 2018/19 have increased, but it is 278 imperative that practitioners in elite football understand that player running load profiles are changing 279 from season-to-season. Due to the inter-positional differences, it is key that staff consider the 280 contextual influence upon distances to inform the training prescription at their club, focused within 281 their respective game model. This increase in game running loads suggest practitioners are required 282 to prepare players for these greater demands, but we suggest this should be achieved by considering 283 ecological dynamics and incorporating contextual information such as position-specific conditioning 284 i.e., training that relates to key game moments, due to the positional running load differences seen. 285 The variability in the averages suggest that a long-term average alone may not be enough to build a 286 full understanding. Running load is likely to be affected by environmental and situational factors 287 around the player within the same game and from one game to another.

288 Running loads show differences between positions from season-to-season. Findings in the present 289 study detail that small to moderate increases in TD, HID and SprD were found for team totals in the 290 EPL between 2014 and 2019. Positional analysis highlights significant increases in HID for all positions 291 except GK, with SprD and TD significantly increasing for all positions except for CM/AM/GK and 292 WM/DM respectively. Trivial to small differences were found in team and positional TD, HID and SprD, 293 which when combined sees a bigger increase in running load over the time period analysed. This is an 294 important consideration for sports scientists responsible for the physical preparation of players for 295 competition and recovery strategies between games. As we did not find consistent increases for all 296 the seasons and all positions, this highlights the need for practitioners to understand the individual 297 player demands when assessing and preparing them for training and competition. Although, it is 298 important for practitioners to contextualise this information to establish why some teams, positions 299 and players run more than others and how this may affect match outcome. It is also suggested that 300 these trends need to be updated regularly to monitor running load patterns and see how the physical 301 demands are increasing for players in an ever-increasing fixture schedule.

#### 302 Future Research

303 Running load is only one aspect of the game and an interaction between a myriad of factors is required 304 to create the optimal chance of winning a football match. Future studies should consider the effect of 305 running outputs on match outcome in the EPL. Previously, running has been suggested to be an 306 important aspect of a team's chance of winning (26,27). This may mislead practitioners and 307 underestimate the complexity of the game. Contextualisation of the running, how it relates to tactical 308 and formational change and an understanding of how different types of running influences match 309 outcome is needed. Emphasising the importance for researchers and practitioners to search for the 310 process, and how these impact upon team success. It is important to note that running more may not be the desired outcome, but rather to be in the right place at the right time (28). Importantly, given
that football is not a 'brainless task' (29) the effects of increased running load may increase mental
fatigue for a player, which may affect the players decision making (30).

314 The incorporation of tactical elements within the physical data has started to be explored (22). 315 Additional tactical information in the future may provide an understanding as to whether players are 316 able to run more efficiently, affecting the movement of the team and increasing the chances of 317 successful outcomes (e.g. pass / goal). The speed of which certain movements are performed may 318 affect the chances of success and may determine the times in which a player should run faster or 319 more. Should this be a possibility, a better understanding from the player may preserve their running 320 load; allowing the player to "keep more in the tank" through pacing strategies (31) for the pertinent 321 moments in the game or for the next fixture.

Although this research is an update on previous findings, it is important practitioners begin to look at if there are optimal moments in a game to run, which may increase potential for team success.

#### 324 Limitations

325 Running load involves extensive (e.g. HID and SprD) and intensive (e.g. acceleration and deceleration) 326 measures (32). This paper focuses primarily on the extensive load of football. HID includes SprD within 327 that which may contribute to some of the findings. These metrics were chosen due to their use with 328 practitioners in football (1). It is also important to understand that a key part of the running load in 329 football is the intensive load (acceleration and decelerations). Current optical tracking technologies 330 are not capable of accurately determining acceleration and deceleration efforts (33), hence why they 331 were not analysed in this study. However, research has suggested that intensive outputs may play a significant role in match play (2,34). Future research needs to look at this over multiple teams and 332 333 seasons to see if this is a contributing factor towards team success.

334

#### 335 Disclosure of Interest

336 The authors report no conflict of interest

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#### 338 Additional

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## 341 <u>References</u>

342 343 344	1.	Akenhead R, Nassis GP. Training Load and Player Monitoring in High-Level Football: Current Practice and Perceptions. Int J Sports Physiol Perform. 2016 Jul;11(5):587–93.
345 346 347 348	2.	Harper DJ, Carling C, Kiely J. High-Intensity Acceleration and Deceleration Demands in Elite Team Sports Competitive Match Play: A Systematic Review and Meta-Analysis of Observational Studies. Sports Med. 2019 Dec;49(12):1923–47.
349 350 351 352	3.	Barnes C, Archer DT, Hogg B, Bush M, Bradley PS. The evolution of physical and technical performance parameters in the English Premier League. Int J Sports Med. 2014 Dec;35(13):1095–100.
353 354 355 356	4.	Bush M, Barnes C, Archer DT, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English Premier League. Human Movement Science. 2015 Feb 1;39:1–11.
357 358 359 360	5.	Folgado H, Gonçalves B, Sampaio J. Positional synchronization affects physical and physiological responses to preseason in professional football (soccer). Res Sports Med. 2018 Mar;26(1):51–63.
361 362 363 364	6.	Nassis GP, Massey A, Jacobsen P, Brito J, Randers MB, Castagna C, et al. Elite football of 2030 will not be the same as that of 2020: Preparing players, coaches, and support staff for the evolution. Scandinavian Journal of Medicine & Science in Sports. 2020;30(6):962–4.
365 366 367 368	7.	Taberner M, Allen T, O'Keefe J, Richter C, Cohen D, Harper D, et al. Interchangeability of optical tracking technologies: potential overestimation of the sprint running load demands in the English Premier League. Science and Medicine in Football. 2022 Jul 27;0(0):1–10.
369 370 371	8.	Linke D, Link D, Lames M. Football-specific validity of TRACAB's optical video tracking systems. PLOS ONE. 2020 Mar 10;15(3):e0230179.
372 373	9.	FIFA Quality Performance Reports For EPTS [Internet]. 2019 [cited 2022 Aug 15]. Available from: <a href="https://www.fifa.com/technical/football-technology/standards/epts/origin1904-">https://www.fifa.com/technical/football-technology/standards/epts/origin1904-</a>

374	p.cxm.fifa.com/technical/football-technology/standards/epts/fifa-quality-performance-
375 376	<u>reports-for-epts</u>
377 378 379 380	<ol> <li>Taberner M, O'Keefe J, Flower D, Phillips J, Close G, Cohen DD, et al. Interchangeability of position tracking technologies; can we merge the data? Science and Medicine in Football. 2020 Jan 2;4(1):76–81.</li> </ol>
381 382 383	<ol> <li>Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc. 2009 Jan;41(1):3–13.</li> </ol>
384 385 386	<ol> <li>van der Kruk E, Reijne MM. Accuracy of human motion capture systems for sport applications; state-of-the-art review. Eur J Sport Sci. 2018 Jul;18(6):806–19.</li> </ol>
387 388 389 390	<ol> <li>Ellens S, Hodges D, McCullagh S, Malone JJ, Varley MC. Interchangeability of player movement variables from different athlete tracking systems in professional soccer. Science and Medicine in Football. 2022 Jan 2;6(1):1–6.</li> </ol>
391 392 393 394	<ol> <li>Moura FA, Martins LEB, Anido RO, Ruffino PRC, Barros RML, Cunha SA. A spectral analysis of team dynamics and tactics in Brazilian football. J Sports Sci. 2013;31(14):1568– 77.</li> </ol>
395 396 397 398	15. Harper DJ, Sandford GN, Clubb J, Young M, Taberner M, Rhodes D, et al. Elite football of 2030 will not be the same as that of 2020: What has evolved and what needs to evolve? Scand J Med Sci Sports. 2021 Feb;31(2):493–4.
399 400 401 402	<ol> <li>Sarmento H, Clemente FM, Araújo D, Davids K, McRobert A, Figueiredo A. What Performance Analysts Need to Know About Research Trends in Association Football (2012- 2016): A Systematic Review. Sports Med. 2018 Apr;48(4):799–836.</li> </ol>
403 404 405 406	<ol> <li>Maneiro R, Casal CA, Álvarez I, Moral JE, López S, Ardá A, et al. Offensive Transitions in High-Performance Football: Differences Between UEFA Euro 2008 and UEFA Euro 2016. Front Psychol. 2019;10:1230.</li> </ol>

407	18.	Bortnik L, Burger J, Rhodes D. The mean and peak physical demands during transitional play
408		and high pressure activities in elite football. Biol Sport. 2022;40(1):1055-64.
409		
410	19.	Sarmento H, Marcelino R, Anguera MT, CampaniÇo J, Matos N, LeitÃo JC. Match analysis
411		in football: a systematic review. J Sports Sci. 2014 Dec;32(20):1831-43.
412		
413	20.	Li C, Zhao Y. Comparison of Goal Scoring Patterns in "The Big Five" European Football
414		Leagues. Frontiers in Psychology [Internet]. 2021 [cited 2022 Aug 13];11. Available from:
415		https://www.frontiersin.org/articles/10.3389/fpsyg.2020.619304
416 417 418 419 420 421	21.	Aquino R, Gonçalves LG, Galgaro M, Maria TS, Rostaiser E, Pastor A, et al. Match running performance in Brazilian professional soccer players: comparisons between successful and unsuccessful teams. BMC Sports Sci Med Rehabil. 2021 Dec;13(1):93.
422	22.	Bradley PS, Ade JD. Are Current Physical Match Performance Metrics in Elite Soccer Fit for
423		Purpose or Is the Adoption of an Integrated Approach Needed? Int J Sports Physiol Perform.
424		2018 May 1;13(5):656–64.
425 426		
427 428 429 430	23.	Duhig S, Shield AJ, Opar D, Gabbett TJ, Ferguson C, Williams M. Effect of high- speed running on hamstring strain injury risk. Br J Sports Med. 2016 Dec 1;50(24):1536–40.
431 432 433 434	24.	Frencken W, Lemmink K, Delleman N, Visscher C. Oscillations of centroid position and surface area of soccer teams in small-sided games. European Journal of Sport Science. 2011 Jul 1;11(4):215–23.
435	25.	Abbott W, Brickley G, Smeeton NJ. An individual approach to monitoring locomotive
436		training load in English Premier League academy soccer players. International Journal of
437		Sports Science & Coaching. 2018 Jun 1;13(3):421-8.
438		
439	26.	Andrzejewski M, Konefał M, Chmura P, Kowalczuk E, Chmura J. Match outcome and
440		distances covered at various speeds in match play by elite German soccer players.
441		International Journal of Performance Analysis in Sport. 2016 Dec 1;16(3):817-28.
442		

443	27. Andrzejewski M, Chmura P, Konefał M, Kowalczuk E, Chmura J. Match outcome and
444	sprinting activities in match play by elite German soccer players. J Sports Med Phys Fitness.
445	2018 Jun;58(6):785–92.
446	
447	28. Dupont G, McCall A. Soccer Science. In: Human Kinetics [Internet]. 2016 [cited 2022 Aug
448	13]. Available from: https://us.humankinetics.com/products/soccer-science
449 450 451 452	29. Coutts AJ. Fatigue in football: it's not a brainless task! J Sports Sci. 2016 Jul;34(14):1296.
453 454 455	<ol> <li>Smith M, Zeuwts L, Lenoir M, Hens N, de Jong L, Coutts A. Mental fatigue impairs soccer-specific decision-making skill. Journal of Sports Sciences. 2016 Mar 7;34.</li> </ol>
456	31. Waldron M, Highton J. Fatigue and pacing in high-intensity intermittent team sport: an
457	update. Sports Med. 2014 Dec;44(12):1645–58.
458 459 460 461	<ul><li>32. Walker GJ, Hawkins R. Structuring a Program in Elite Professional Soccer. Strength &amp; Conditioning Journal. 2018 Jun;40(3):72–82.</li></ul>
462 463 464 465 466 467	33. Wu LY, Swartz TB. The calculation of player speed from tracking data. International Journal of Sports Science & Coaching. 2022 Sep 20;17479541221124036.
107	
468	34. Rhodes D, Valassakis S, Bortnik L, Eaves R, Harper D, Alexander J. The Effect of High-
469	Intensity Accelerations and Decelerations on Match Outcome of an Elite English League Two
470 471	Football Team. International Journal of Environmental Research and Public Health. 2021 Jan;18(18):9913.