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The Evolution of Physical and Technical Performance Parameters in the English Premier League

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Key words

- longitudinal
- high-intensity
- sprinting
- passing
- football

Abstract

This study examined the evolution of physical and technical soccer performance across a 7-season period in the English Premier League. Match performance observations ($n = 14\,700$) were analysed for emergent trends. Total distance covered during a match was ~2% lower in 2006–07 compared to 2012–13. Across 7 seasons, high-intensity running distance and actions increased by ~30% (890 ± 299 vs. $1\,151 \pm 337$ m, $p < 0.001$; ES: 0.82) and ~50% (118 ± 36 vs. 176 ± 46 , $p < 0.001$; ES: 1.41), respectively. Sprint distance and number of sprints increased by ~35% (232 ± 114 vs. 350 ± 139 m, $p < 0.001$; ES: 0.93) and ~85% (31 ± 14 vs. 57 ± 20 , $p < 0.001$; ES: 1.46),

respectively. Mean sprint distance was shorter in 2012–13 compared to 2006–07 (5.9 ± 0.8 vs. 6.9 ± 1.3 m, $p < 0.001$; ES: 0.91), with the proportion of explosive sprints increasing (34 ± 11 vs. $47 \pm 9\%$, $p < 0.001$; ES: 1.31). Players performed more passes (35 ± 17 vs. 25 ± 13 , $p < 0.001$; ES: 0.66) and successful passes ($83 \pm 10\%$ vs. $76 \pm 13\%$, $p < 0.001$; ES: 0.60) in 2012–13 compared to 2006–07. Whereas the number of short and medium passes increased across time ($p < 0.001$; ES > 0.6), the number of long passes varied little ($p < 0.001$; ES: 0.11). This data demonstrates evolution of physical and technical parameters in the English Premier League, and could be used to aid talent identification, training and conditioning preparation.

Introduction

Soccer match play is characterized by brief bouts of high-intensity linear and multidirectional activity interspersed with longer, variable recovery periods [17]. There is a commonly held belief amongst coaches and players that there has been an increase in both the physical and technical demands of the game. However, this position currently lacks evidence. Technical rather than physical factors have been shown to better differentiate between competitive standards in elite soccer [3]. There is, however, a lack of research to map the development of the game and to quantify whether this perception of physical and technical evolution is indeed a reality.

Other team sports such as handball and Australian rules football have been shown to have evolved over time, possibly due to a combination of rule changes and improvements in physical, technical and tactical preparation [2, 15]. A comparison of the intensity of English League soccer matches played in the 1991–92 and 1997–98 seasons found increased incidence of dribbling, passing, crossing and running with the ball [20].

Similarly, increased passing rates and ball speeds have been observed in World Cup final matches across a 44-year period (1966–2010) [18]. Although this research provides insight into the technical development of soccer match play, no consideration was given to the physical performance of players.

To gain a more comprehensive understanding of the evolving patterns of soccer, large scale studies to evaluate both physical and technical development are needed which include recent observations across multiple seasons and control for contextual factors such as playing position and phase of season [9]. The aim of this study was thus to examine the evolution of the physical and technical performances parameters in the English Premier League (EPL) using the largest controlled sample published to date.

Materials and Methods

Match performance data were collected from 7 consecutive EPL seasons (2006–07 to 2012–13) using a multiple-camera computerized tracking

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system (Prozone Sports Ltd[®], Leeds, UK). The validity and reliability of this tracking system has been previously quantified [8,9]. The investigation was conducted in accordance with the Declaration of Helsinki and meets the ethical standards of the International Journal of Sports Medicine [12].

Data were derived from Prozone's Trend Software and consisted of 1036 individual players across 22846 player observations. Original data files were de-sensitized. Individual match data were included only if players had completed the entire 90 min, and matches were excluded if a player dismissal occurred. The total number of observations were substantially different across season (2006–07 to 2012–13), phase of season (Aug–Nov, Dec–Feb, Mar–May), position (attackers, centre backs, central midfielders, full-backs, wide midfielders), location (home and away) and team standard based on final league ranking (A: 1st–4th, B: 5th–8th, C: 9th–14th, D: 15th–20th). The original data were re-sampled using a stratification algorithm in order to balance the number of samples for each factor, thus minimising errors when applying statistical tests. The re-sampling was achieved using the stratified function in the R package “devtools” (R Development Core Team) using the procedures of Wickham & Chang [19] with 14700 player observations included for further analyses (● Table 1).

Activities were coded into the following: standing (0–0.6 km·h⁻¹), walking (0.7–7.1 km·h⁻¹), jogging (7.2–14.3 km·h⁻¹), running (14.4–19.7 km·h⁻¹), high-speed running (19.8–25.1 km·h⁻¹) and sprinting (>25.1 km·h⁻¹). Total distance represented the summation of distances in all categories. High-intensity running consisted of the combined distance in high-speed running and sprinting (≥19.8 km·h⁻¹) and was separated into 3 subsets based on the teams' possession status: with (WP) or without ball possession (WOP) and when the ball was out of play (BOOP). Sprinting was differentiated into explosive actions (entry into the sprint zone with no excursion into the high-speed zone in the previous 0.5 s period) or leading (entry into the sprint zone via an excursion of 0.5 s or more into the high-speed zone) [9]. Matches were concomitantly coded for technical events such as the number of passes, successful passes, received passes, touches

per possession, dribbles, shots, events of tackles/tackled, crosses, final third entries, possession won and lost.

One-way independent-measures analysis of variance (ANOVA) tests were used to compare each season with Dunnett's *post hoc* tests being used to verify localised differences. Statistical significance was set at $p < 0.05$. The effect size (ES) was calculated to determine the meaningfulness of the difference [1], and magnitudes were classified as trivial (<0.2), small (>0.2–0.6), moderate (>0.6–1.2) and large (>1.2–2.0). All analyses were conducted using statistical software (R Development Core Team), and data visualisation was carried out using the Deducer Interface for the R statistical programming language.

Results



Total distance covered during a match was lower in 2006–07 compared to 2012–13 (10679±956 vs. 10881±885 m) but varied by a trivial magnitude across the 7 seasons (● Fig. 1a, $p < 0.001$; ES: 0.01–0.22). High-intensity running distance increased from 890±299 m in 2006–07 to 1151±337 m in 2012–13 (● Fig. 1b, $p < 0.001$; ES: 0.82), with an associated increase in the number of high-intensity running actions (118±36 vs. 176±46, $p < 0.001$; ES: 1.41). High-intensity running WP was lower in 2006–07 (373±238 m) compared with other seasons, apart from 2008–09 (389±242 m), peaking at 478±260 m in 2012/13 ($p < 0.001$; ES: 0.42). High-intensity running WOP was lower in 2006–07 (451±162 m) compared to other seasons, peaking in 2012–13 (589±198 m, $p < 0.001$; ES: 0.76). Trivial-small differences in the proportion of high-intensity running WP, WOP and BOOP were observed between seasons ($p = 0.16, 0.34$ and 0.001 , respectively; ES: 0.04–0.22). Total sprint distance increased from 232±114 to 350±139 m between 2006–07 and 2012–13 (● Fig. 1c; $p < 0.001$; ES: 0.93). ● Fig. 2a shows a 2D kernel (Gaussian) density estimation of the number of sprints against the percentage of explosive spring over the 7 Premiership seasons. The plot shows the distribution of data is moving positively both along the x and y axis, indicating both an

Table 1 Re-sampled data from stratified random analysis. Data in parentheses indicate the relative proportion of the total sample as a percentage.

Season	2006–07	2007–08	2008–09	2009–10	2010–2011	2011–12	2012–13	Total
Month								
Aug–Nov	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	4900 (33)
Dec–Feb	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	4900 (33)
Mar–May	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	700 (33)	4900 (33)
Location								
home	1083 (52)	1078 (51)	1050 (50)	1069 (51)	1051 (50)	1049 (50)	1019 (49)	7399 (50)
away	1017 (48)	1022 (49)	1050 (50)	1031 (49)	1049 (50)	1051 (50)	1081 (51)	7301 (50)
Position								
AT	315 (15)	310 (15)	309 (15)	308 (15)	306 (15)	306 (15)	298 (14)	2152 (15)
CB	534 (25)	527 (25)	523 (25)	539 (26)	554 (26)	546 (26)	569 (27)	3792 (26)
CM	459 (22)	463 (22)	465 (22)	464 (22)	454 (22)	452 (22)	443 (21)	3200 (22)
FB	475 (23)	489 (23)	493 (23)	487 (23)	491 (23)	487 (23)	498 (24)	3420 (23)
WM	317 (15)	311 (15)	310 (15)	302 (14)	295 (14)	309 (15)	292 (14)	2136 (15)
Standard								
A (1 st –4 th)	319 (15)	245 (12)	339 (16)	360 (17)	424 (20)	446 (21)	386 (18)	2519 (17)
B (5 th –8 th)	509 (24)	436 (21)	407 (19)	385 (18)	459 (22)	347 (17)	422 (20)	2965 (20)
C (9 th –14 th)	486 (23)	719 (34)	656 (31)	713 (34)	587 (28)	636 (30)	651 (31)	4448 (30)
D (15 th –20 th)	786 (37)	700 (33)	698 (33)	642 (31)	630 (30)	671 (32)	641 (31)	4768 (32)
Overall	2100	2100	2100	2100	2100	2100	2100	14700

Month: Start of season (Aug–Nov), Middle of season (Dec–Feb) and End of season (Mar–May). Positions: AT = Attackers, CB = Centre backs, CM = Central midfielders, FB = Full-backs and WM = Wide midfielders

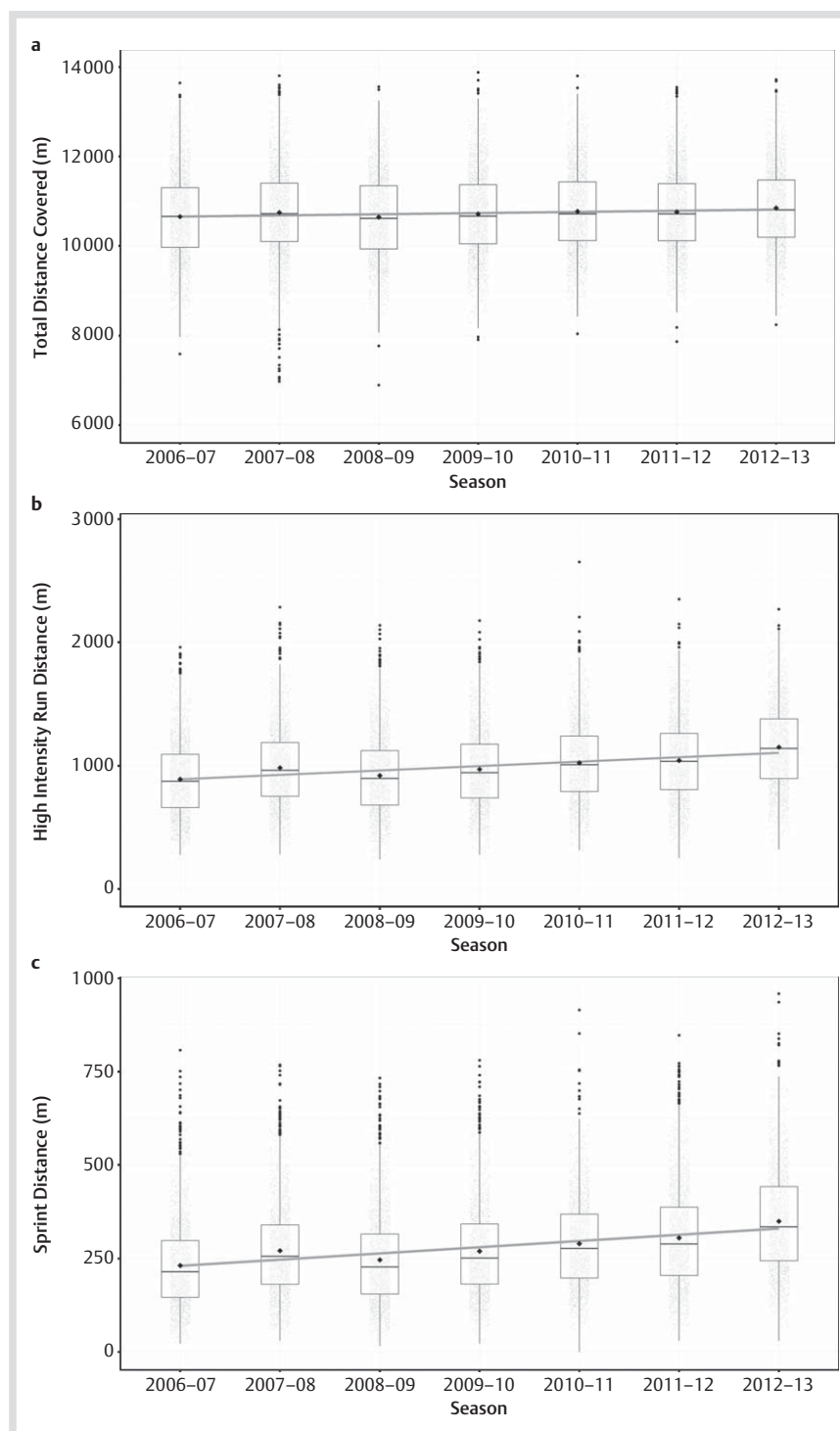


Fig. 1 a Box and whisker plots with median values interquartile ranges and outliers for the total distance covered in matches across 7 seasons of the English Premier League. Each player's observation is jittered and included as a small dot around box and whisker plots (diamond within box is the mean value for each season). The larger dots at the top and bottom of boxes are outliers. Line represents the regression line and 95% confidence interval. b Box and whisker plots with median values interquartile ranges and outliers for the high-intensity running distance covered in matches across 7 seasons of the English Premier League. Each player's observation is jittered and is included as a small dot around box and whisker plots (diamond within box is the mean value for each season). The larger dots at the top and bottom of boxes are outliers. Line represents the regression line and 95% confidence interval. c Box and whisker plots with median values interquartile ranges and outliers for the sprinting distance covered in matches across 7 seasons of the English Premier League. Each player's observation is jittered and is included as a small dot around box and whisker plots (diamond within box is the mean value for each season). The larger dots at the top and bottom of boxes are outliers. Line represents the regression line and 95% confidence interval.

increasing number of sprints (31 ± 14 vs. 57 ± 20 , $p < 0.001$; ES: 1.46) and an increasing proportion of these sprints being explosive in nature (34 ± 11 vs. $47 \pm 9\%$, $p < 0.001$; ES: 1.31). Across the same period the average distance covered per sprint decreased (6.9 ± 1.3 vs. 5.9 ± 0.8 m, $p < 0.001$; ES: 0.91). Maximal running speed attained increased from 9.12 ± 0.43 to 9.55 ± 0.40 m.s⁻¹ between 2006–07 and 2012–13, respectively ($p < 0.001$; ES: 1.02).

• **Table 2** summarises technical performance across the seasons. Players performed ~40% more passes ($p < 0.001$, ES: 0.64, 0.66) and received ~17% more passes ($p < 0.001$, ES: 0.76, 0.78), with a greater percentage of successful passes in 2011–12 and 2012–13 ($p < 0.001$; ES: 0.68 and 0.60, respectively) compared to

2006–07. Whilst the number of short and medium passes followed a similar pattern to total passes ($p < 0.001$; ES > 0.6), the number of long passes varied little over the seasons ($p < 0.001$; ES: 0.11). The number of shots taken varied little between seasons ($p = 0.20$; ES: 0.01–0.06), as did the number of tackles made, tackled events and final third entries ($p < 0.001$; ES: 0.06–0.27). • **Fig. 2b** displays the interaction between the number of passes made and the percentage of successful passes with increases in the mean values of both indicators occurring across seasons. The percentage of occurrences of players with a passing success rate of <70% decreased from 26% in 2006–07 to 9% in 2012–13.

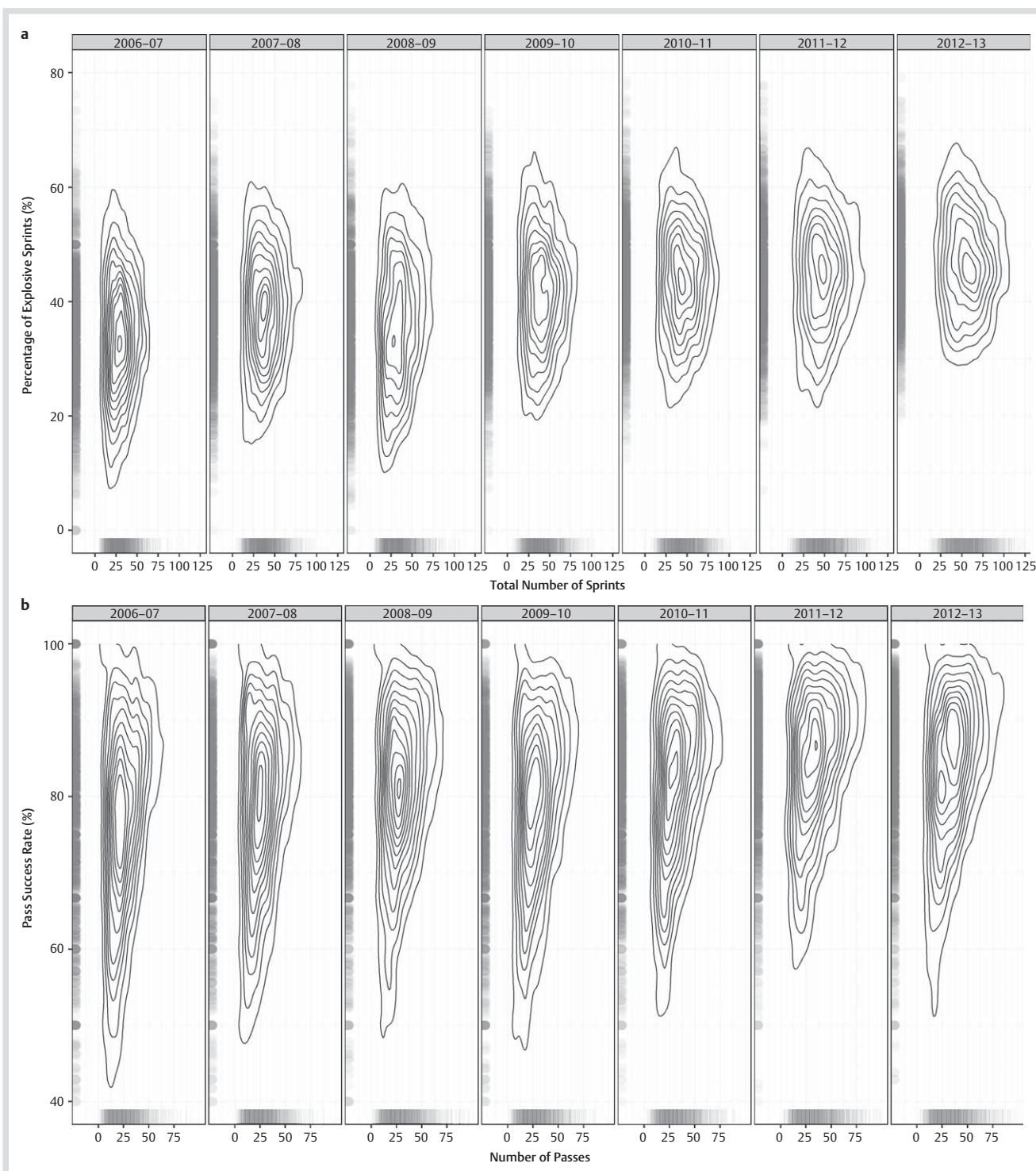


Fig. 2 **a** Visualization of data trends using two-dimensional kernel density plots of number of sprints and the relative proportion of those sprints that were explosive in nature (darker shades denote higher density within distribution). **b** Visualization of data trends using two-dimensional kernel density plots of number of passes and pass success rate in the English Premier League. Rug plots are also superimposed onto the x and y axis to provide insight into the distribution within each variable (darker shades denote higher density within distribution).

Discussion

The present study analysed the largest sample of player observations in EPL soccer published to date and builds on previous research [11] by using a randomized stratification algorithm to allow seasonal, tactical and contextual factors to be accounted for. Our data demonstrate that whilst total distance covered during a match remained relatively constant, high-intensity run-

ning distance and sprinting distance increased by ~30–35% between 2006–07 and 2012–13. Both total and high-intensity running distances have previously been used to represent the physical demands of soccer match play [5,9], though high-intensity running would seem to be a better measure as it correlates well with physical capacity [4] and discriminates between competitive standard and gender [3,14]. The findings of the present study would support this view [6,20] and highlight the increasing

Table 2 Technical indicators across the 2006–07 to 2012–13 seasons. Data are displayed as means and standard deviations.

Variables	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13
passes	25.3±13.4	27.0±13.7†	30.8±16.0†	29.0±14.6†	32.1±15.1†	35.5±18.2†	35.4±17.1†
successful passes (%)	76.3±12.7	78.0±12.1†	80.7±10.9†	78.2±11.8†	81.1±10.4†	84.0±9.6†	83.3±10.1†
short passes	6.1±4.3	7.0±4.7†	7.9±5.3†	7.5±5.2†	8.3±5.2†	9.6±6.4†	9.4±6.0†
medium passes	13.4±8.7	14.3±8.8*	16.7±10.3†	15.5±9.4†	17.7±10.0†	19.7±11.9†	19.8±11.3†
long passes	5.7±4.0	5.7±4.0	6.2±4.5#	5.9±4.3	6.2±4.3#	6.2±4.6†	6.2±4.5†
passes received	18.8±11.7	20.6±11.7†	24.3±14.0†	22.3±12.5†	25.5±13.2†	29.5±16.1†	29.2±14.9†
touches	1.9±0.6	2.0±0.5*	2.0±0.5†	1.9±0.5	2.0±0.5*	2.0±0.5†	2.1±0.5†
shots	1.2±1.4	1.2±1.4	1.2±1.5	1.2±1.5	1.2±1.5	1.3±1.6	1.2±1.5
clearances	3.0±2.9	3.4±3.2†	2.6±2.5†	2.8±2.6#	2.4±2.3†	2.1±2.2†	2.3±2.3†
dribbles	0.1±0.4	0.2±0.5	0.3±0.7†	0.5±1.0†	0.8±1.4†	1.2±1.7†	0.6±1.1†
tackles	3.2±2.2	2.6±2.0†	3.3±2.3	3.2±2.3	3.1±2.1	2.9±2.1#	3.0±2.2
tackled	2.8±2.7	2.3±2.3†	2.9±2.7	2.8±2.8	2.6±2.6	2.6±2.6	2.6±2.5*
final third entries	5.9±4.0	5.9±3.8	5.8±3.9†	5.9±3.8	5.7±3.7†	5.4±3.6†	5.2±3.6†
possessions won	19.6±9.4	19.7±9.4	18.1±8.9†	19.0±9.1	17.8±8.6†	16.4±8.0†	16.4±7.7†
possessions lost	22.8±6.9	22.7±7.0	21.0±6.6†	22.1±6.9#	20.5±6.7†	19.3±6.3†	19.3±6.3†

* $p < 0.05$, # $p < 0.01$ and † $p < 0.001$ denote difference from 2006–07

demands of the EPL. Williams et al. reported increases in the number of technical events (passes, dribbles and crosses) in the top tier of English soccer between the 1991–92 and 1997–98 seasons [20]. Increasing passing rates and ball speeds were observed in World Cup finals across a 44-year period [18]. The authors speculated that these trends could be related to longer stoppages for set-pieces with greater recovery periods allowing more intense activity when play is resumed, whereas in the present study increased high-intensity work was performed despite reduced recovery periods. The trend for increased physical and technical performance in the present study is reflective of an evolution within the game which may be a consequence of developing physical, technical and tactical preparation of players.

Sprinting comprises of only 1–4% of the total distance covered in a soccer match, but despite its infrequent nature it typically occurs during significant moments [9]. Across the timeframe of the present study, distance covered sprinting increased by ~35% and can be attributed to shorter but more frequent sprinting bouts during matches. The growing physicality of the English Premier League is further supported by the fact that between 2006–07 and 2012–13, the absolute number of both explosive and leading sprints increased and that latterly a much higher proportion of sprints was performed explosively. Whilst previous research on EPL players found that the proportion of explosive and leading sprints was related to playing position [9], ours is the first to report longitudinal changes. Maximal running speed was also found to increase substantially from 2006–07 to 2012–13. Therefore, if players are producing shorter more explosive sprints but attaining higher maximal running speeds, then the acceleration capability of players has developed, which may increase injury propensity, and practitioners may need to develop appropriate pre-conditioning exercises [13]. Interestingly, patterns of injury incidence reported in UEFA audits have remained unchanged across a comparable 7-year period [10], although the data in that study were collected from 23 elite European clubs and not exclusively from the EPL, which is renowned for its physicality.

Match analysis research typically quantifies the distance players cover in various movement categories without factoring in technical parameters [9,16]. Over the period of this study we found that players performed ~40% more passes, with a greater percentage of successful passes occurring in 2012–13 (84%) compared to 2006–07 (76%). This information, combined with

increased numbers of short and medium passes (with little change in the number of long passes), suggests that there has been an increase in passing tempo over recent seasons, resulting in greater involvement with the ball. The increased pass success rate may be explained partly by the increased proportion of short to medium passes, which are likely to be more successful than long passes. Fast transition of the ball to offensive areas of the pitch through a combination of high pass rates and ball speed is advantageous in elite soccer [18], and has been reported to have a strong association with success [6]. This increase in technical performance is further supported by the percentage of player occurrences with a passing success rate of <70%, identified as a minimum requirement in elite soccer [7], decreasing from 26% in 2006–07 to 9% in 2012–13.

These data reflect the fact that over the 7-season period in question, the physical and technical demands of EPL soccer have increased substantially. Coaches and sports scientists should be mindful of this when developing training and conditioning practices.

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