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Body composition characteristics of senior male players in the English Premier and Football Leagues: insights from dual-energy X-ray absorptiometry

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Abstract

Body composition assessments in professional male football often lack sport-specific evidence, risking mismanagement of player health and performance. This study described dual-energy X-ray absorptiometry (DXA)-derived values by playing position, ethnicity, competition level, and seasonal timepoints. A total of 343 players (mean \pm SD: age = 22.6 ± 4.6 years; stature = 182.0 ± 6.9 cm; body mass = 79.1 ± 8.6 kg) from the English Premier League ($n = 76$) and English Football League ($n = 267$) completed 939 scans over a 10-year period (2014–2024) using DXA (Lunar iDXA, GE Healthcare), with repeat measurements taken across the season. Players were sub-classified as Goalkeepers ($n = 32$), Central Defenders ($n = 55$), Wide Defenders ($n = 64$), Central Midfielders ($n = 73$), Wide Midfielders ($n = 62$), and Forwards ($n = 57$). Body composition ranges specific to position were identified for bone mass (3.5–4.2 kg), fat-free soft tissue mass (61.2–69.6 kg), fat mass (9.1–13.5 kg), and percentage body fat (11.6–15.4%). Significant differences in bone, fat-free soft tissue, and fat mass were observed between playing positions, ethnicity, and league level ($p < 0.050$). Across a single season, fat-free soft tissue mass increased significantly, while fat mass decreased (both: $p < 0.001$), indicating positive physiological adaptations from moderate body mass increases rather than performance concerns. These findings indicate that body fat values above the commonly cited $< 10\%$ threshold are regularly observed in elite male footballers, suggesting the need for more individualised targets over generic team-wide standards. Providing the largest criterion-measured dataset for professional male footballers, this study supports athlete-centred, position-specific decision-making to optimise player health and performance.

Keywords Body composition, Football, Dual x-ray absorptiometry, Soccer

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Introduction

English professional football currently has 5,582 senior male players contracted to 92 professional league clubs, competing across the English Premier League (EPL), English Football League (EFL), and National Conference (FIFA, [11]). Body composition assessments are widely used within this context as a measure of physiological readiness, with assumptions that variations in fat and fat-free soft tissue mass impact performance [6, 33]. Previous research suggests that higher body fat values may reduce acceleration capacity, movement efficiency, and increase injury risk [10, 16, 34]. In contrast, increased fat-free soft tissue mass - comprising water, protein, mineral, glycogen, and essential lipid [36] - is associated with greater force and power generation, which may enhance sprint performance and physical robustness [1]. However, despite their routine use, body composition assessments are often implemented without strong football-specific evidence supporting their role in health or performance enhancement [7, 22, 24, 32]. There remains a need to determine whether current benchmarks applied to professional players are appropriate across different playing positions, leagues, and ethnic groups.

Beyond its role in physical performance, body composition monitoring can negatively impact player health and well-being if conducted inappropriately. Pressures associated with arbitrary fat percentage targets, often based on limited or non-football-specific research [7], can lead to problematic low energy availability, relative energy deficiency in sport (REDs) [22, 26] and disordered eating behaviours, with 19% of athletes worldwide engaging in behaviours including restrictive dieting, bingeing, or purging [13]. Foo et al., [12] report that EPL players who fail to meet culturally enforced body composition standards are often perceived as unprofessional or lazy, leading to increased stress, anxiety, and extreme dietary practices. One player described the pressure to meet targets, stating: *"You literally do no carbs to go down to that target. I didn't feel good... I didn't feel like I had energy to train"* [12]. The influence of managers, who often dictate food provision and enforce strict assessment methods, can further heighten this pressure, with players fearing that failing to meet body composition targets may impact selection. Additionally, performance nutritionists in the EPL report struggling to implement evidence-based practices due to arbitrary targets imposed by management, with one practitioner questioning: *"I often hear numbers thrown around, like 'I want them under 10%', but what's that based on?"* [8]. This misalignment between best practice - "there is no single value for either body mass or fat mass against which targets or judgements should be made" [7] - and applied practice, highlights the need for high-quality descriptive data to establish evidence-based

benchmarks for effective body composition management in professional football.

Advancements in measurement technology have led to the increased use of dual-energy X-ray absorptiometry (DXA) for body composition assessment. Dual-energy X-ray absorptiometry provides precise estimates of total and regional bone, fat, and fat-free soft tissue mass, offering superior accuracy to skinfold callipers and bioelectrical impedance analysis [14, 15]. Its speed (~ 7 min per scan) and low radiation exposure make it preferable to other imaging techniques such as magnetic resonance imaging or computed tomography [1, 18]. Despite this, inconsistencies remain in how DXA is used, with most football-based research relying on the Hologic Discovery QDR Series [25, 34]. In contrast, the GE Lunar DXA system - widely used in applied elite sport settings - has been underrepresented in published research involving professional footballers, limiting the availability of system-specific reference values for practitioners. Furthermore, DXA studies in male football have typically been restricted to sample sizes from single squads [24, 25, 34, 39], with the largest published dataset profiling 64 EPL players over 15 years ago [34]. Expanding this dataset to include a broader representation of professional players across the football league pyramid is essential to establish meaningful descriptive data.

Evidence suggests that body composition varies by playing position and ethnicity, yet inconsistencies in findings highlight the need for further investigation. Sutton et al., [34] reported that goalkeepers had between 2 and 3% higher body fat percentages than outfield players, despite comparable fat-free soft tissue and bone mass. In contrast, Milsom et al., [25] found that goalkeepers had greater fat-free mass than midfielders (73.5 vs. 62.3 kg) but similar fat mass and body fat percentages in a sample of 27 EPL players. These discrepancies underscore the necessity of establishing position-specific reference ranges for both goalkeepers and outfield players. Ethnicity has also been identified as a factor influencing body composition, with Sutton et al., [34] reporting significantly higher body fat percentages in Caucasian compared to non-Caucasian players, suggesting potential genetic, metabolic, or cultural influences [37]. However, existing studies are limited by small sample sizes, necessitating further research in a larger and more diverse cohort. Likewise seasonal changes in body composition are evident, with studies reporting in-season reductions in fat mass (- 11.9% and - 0.9 kg) and body fat percentage (- 1.3% and - 1.5%), alongside increases in fat-free soft tissue mass (1.3-1.5% and + 0.5 kg) [24, 38]. These fluctuations are likely due to changes in training intensity, match schedules, travel, and recovery demands across different phases of a football season. A deeper understanding of these variations would allow practitioners to

apply body composition data more effectively, ensuring realistic, health-focused, and performance-driven targets for professional male footballers.

Therefore, the present study aims to provide a comprehensive understanding of anthropometric and body composition profiles in professional male footballers by (1) describing normative profiles by playing position, (2) investigating differences by playing position, league, ethnicity, and seasonal timepoints, and (3) identify the best predictors of anthropometric and body composition metrics. By addressing these gaps, this research aims to enhance the application of body composition assessments in professional football, providing practitioners with more robust, evidence-based guidelines for safe and effective player management.

Materials and methods

Study design and participants

The data for this study was collected over a 10-year period (2014–2024) as part of multiple research projects conducted by staff and students at Leeds Beckett University. Participants were male professional footballers contracted to one of seven clubs competing in the EPL, EFL Championship, EFL One, or EFL Two. All players provided informed consent for their data to be used in further research on body composition. Ethical approval was granted by the Carnegie School of Sport Research Ethics Committee (application ref: 126825) for the secondary analysis of data from multiple primary studies, adhering to the Declaration of Helsinki and international research standards. Individual participant consent was obtained in each primary study, ensuring compliance with ethical guidelines for data use in secondary analyses.

Body composition

All measurements followed a standardised protocol. Stature was measured using a stadiometer (SECA Alpha, Birmingham, UK) to the nearest 0.1 cm, and body mass was recorded using electronic scales (SECA Alpha 770, Birmingham, UK) to the nearest 0.1 kg. Participants wore only underwear, removed all jewellery, and were advised to refrain from intensive exercise, alcohol, and caffeine for the preceding 24 h. Participants were encouraged to test in a fasted, euhydrated state with an empty bladder [14, 27].

Each participant underwent a total body scan using the same Lunar iDXA scanner (GE Healthcare, Madison, WI). Scanning was conducted with participants in a supine position, aligned along the central horizontal axis. Legs were fully extended, slightly apart, and secured at the ankles with Velcro straps. Arms were positioned parallel to the body with a ~ 1 cm air gap from the torso, and hands were placed at the sides with thumbs up to ensure

clear region-of-interest segmentation [35]. Standard mode scans lasted approximately 7.5 min.

Regions of interest were segmented at the coracoid process (arms), superior iliac crest and lower ramus (trunk), and femoral neck (legs), following manufacturer guidelines. Analysis was performed using Lunar Encore software (Version 18.0). Throughout the study, the system passed daily calibration and weekly quality assurance tests, with all scans verified by an International Society for Clinical Densitometry (ISCD) certified bone densitometry technologist.

In-vivo total body composition precision measurements (coefficient of variation) at the Leeds Beckett University DXA unit are 0.99% for fat mass, 0.98% for bone mass, and 0.42% for fat-free soft tissue mass (*unpublished lab data*). The Least Significant Change (LSC) values are 2.73% for fat percentage, 2.71% for fat mass and 1.16% for fat-free soft tissue mass. Precision measurements were carried out by one operator scanning 30 athlete participants twice, repositioning between each scan, as recommended by the ISCD's Official Positions. The precision group were male (mean age: 29 ± 6 years, height: 179.4 ± 4.6 cm, and body mass: 81.4 ± 7.7 kg).

The scans provided measurements for total mass (kg), total fat-free soft tissue mass (kg), and total fat mass (kg), with fat mass expressed as a percentage of body fat. Fat-free mass was calculated as the sum of fat-free soft tissue and bone mass. Total body DXA-derived bone variables, including bone mineral content (BMC; g) and bone mineral density (BMD; g/cm^2), were also extracted from the total body composition scan output. These DXA-derived variables were summarised for pre-defined scan regions, including the upper and lower arms, upper and lower legs, trunk, android, gynoid, and total body less head. Additionally, left and right-side measures were recorded, along with asymmetry differences between sides. As these values were derived from total body composition scans rather than site-specific clinical densitometry protocols (e.g., hip or lumbar spine), they were treated as descriptive research variables and not as clinical indicators of bone health.

Statistical analysis

For statistical analysis, participants were grouped by playing position, ethnicity, league, and seasonal timepoint. Playing positions were categorised as goalkeepers, central defenders, wide defenders, central midfielders, wide midfielders, and forwards. Ethnicity classifications included Black, White, Hispanic, Asian, and Other. Participants were also grouped based on their competing league: EPL, EFL Championship, EFL One, or EFL Two. Seasonal timepoints were defined as pre-season (June, July), in-season (September–March), and end-season

(Apr–May) to assess body composition changes over the course of a competitive season.

All analyses were conducted in R (v4.2.0, R Core Team, Vienna, Austria). Generalised mixed models were used to generate reference ranges for anthropometric and body composition data by playing position, via the *glmmTMB* package [5]. Playing position was included as a fixed effect, while participant was treated as a random effect due to repeated observations. Absolute measures were initially modelled using a Gaussian distribution, with model assumptions assessed using the *performance* package [20]. If assumptions were violated, a log-normal distribution was utilised. Relative variables (e.g., body fat percentage) were modelled using a beta distribution. Positional reference ranges were derived through 1,000 simulations, incorporating a random adjustment from the mean based on the participant random effect. The median, along with 68% and 95% prediction intervals, were reported as reference ranges, accompanied by observed minimum and maximum values. To examine differences across ethnicity, competition, and timepoint, a similar modelling approach was applied, with each of these variables included separately as fixed effects, while playing position was retained as a confounder. The *emmeans* package [19] was used to extract and compare estimated marginal means across ethnicities, competitions, and timepoints.

Finally, regression equations were developed by including all independent variables, along with age, as fixed effects. Best subset selection was applied using the *MuMin* package (Bartoń, 2024) to determine the optimal predictive combination of variables, with selection based on the Akaike Information Criterion (AIC). The appropriateness of the developed models was assessed using the four criteria outlined by Riley et al., [31] for multivariable prediction model development. Coefficients from the best subset models were extracted and presented as regression equations. Given the descriptive aim of the study and the use of different model families across outcomes, emphasis was placed on reporting estimated values, prediction intervals, and group comparisons rather than standardised effect size metrics.

Results

A total of 343 participants were purposefully recruited (mean \pm SD: age = 22.6 \pm 4.6 yrs; stature = 182.0 \pm 6.9 cm; body mass = 79.1 \pm 8.6 kg), contributing to a total of 939 scans across multiple time-points. Each participant completed between one and 13 scans (median: 1, interquartile range: 1–3). Of these, 187 participants (54%) completed a single scan, 54 participants completed two scans (16%), and 103 participants (30%) completed three or more scans.

Players were categorised by position as goalkeepers ($n=32$, 96 scans), central defenders ($n=55$, 159 scans), wide defenders ($n=64$, 195 scans), central midfielders ($n=73$, 163 scans), wide midfielders ($n=62$, 194 scans), and forwards ($n=57$, 132 scans). The cohort was predominantly White ($n=236$, 230 scans), with representation also from players identifying as Black ($n=97$, 230 scans), Hispanic ($n=2$, 13 scans), Asian ($n=2$, 13 scans), and other ethnic backgrounds ($n=6$, 22 scans). Participants were drawn from clubs competing in the English Premier League ($n=76$, 363 scans), Championship ($n=234$, 492 scans), League One ($n=63$, 63 scans), and League Two ($n=21$, 21 scans). Data were collected at three key seasonal phases: pre-season ($n=239$, 348 scans), in-season ($n=189$, 442 scans), and end-season ($n=111$, 149 scans).

Anthropometric and body composition data (bone, fat, and fat-free soft tissue mass and percentage body fat) is summarised by playing position, ethnicity, league, and season time-point in Table 1.

Anthropometric and body composition values by playing position

Anthropometric and body composition data is summarised by playing position in Table 1, with additional DXA-derived bone variables presented in the supplementary materials.

Anthropometrics

Goalkeepers were significantly taller than all other positions ($p<0.001$). Central defenders were taller than all positions except goalkeepers ($p<0.001$). Central midfielders were taller than wide defenders ($p<0.001$). Wide midfielders were taller than wide defenders ($p=0.001$).

Goalkeepers and central defenders had significantly greater body mass compared to all other positions ($p<0.001$). Forwards were heavier than wide defenders, central midfielders, and wide midfielders ($p<0.001$).

Body composition

Goalkeepers and central defenders had significantly greater bone mass compared to all other positions ($p<0.001$). Wide defenders had significantly less bone mass than wide defenders and central midfielders ($p<0.001$).

Goalkeepers and central defenders had significantly greater fat-free soft tissue mass than all other positions ($p<0.001$ –0.030). Forwards had significantly greater fat-free soft tissue mass compared to central midfielders, wide defenders, and wide midfielders ($p<0.001$ –0.020). Wide defenders had significantly greater fat-free soft tissue mass than central midfielders ($p=0.001$).

Goalkeepers had significantly greater fat mass compared to all other positions ($p<0.001$ –0.002). Central defenders and forwards had greater fat mass than all

Table 1 Participant characteristics according to playing position, ethnicity, league, and time point. Values are presented as the median, prediction interval (16 – 84%)

Participant Number	Stature (cm)	Body Mass (kg)	Total Bone Mass (kg)	Total Fat-Free Soft Tissue Mass (kg)	Total Fat Mass (kg)	Total Body Fat (%)
Playing Position						
Goalkeeper (n=32)	189.8 (184.1-195.7)	87.4 (80.7-95.2)	4.2 (3.8-4.7)	69.5 (63.2-76.0)	13.5 (10.6-17.5)	15.4 (12.7-18.9)
Central Defender (n=55)	185.3 ^a (179.6-197.6)	85.5 (78.8-93.7)	4.2 (3.8-4.6)	69.6 (63.4-76.2)	10.8 ^a (8.6-13.9)	13.1 ^a (10.7-16.1)
Wide Defender (n=62)	178.7 ^{a,b,d,e} (172.9-184.7)	76.0 ^{ab,f} (68.9-83.5)	3.5 ^{ab,df} (3.1-4.0)	63.5 ^{ab,f} (57.4-69.3)	9.1 ^{ab,f} (7.0-11.7)	12.1 ^a (9.9-14.8)
Central Midfielder (n=73)	180.4 ^{ab} (174.7-186.3)	74.9 ^{ab,f} (68.0-82.5)	3.8 ^{ab} (3.3-4.2)	61.2 ^{ab,cf} (55.8-67.2)	9.6 ^{ab,cf} (7.5-12.2)	12.7 ^a (10.3-15.6)
Wide Midfielder (n=62)	180.4 ^{ab} (174.7-186.3)	74.4 ^{ab,f} (67.6-82.4)	3.6 ^{ab} (3.2-4.1)	61.5 ^{ab,f} (56.0-67.3)	9.1 ^{ab,f} (7.0-11.5)	12.4 ^a (10.1-15.0)
Forward (n=57)	179.4 ^{ab} (173.7-185.1)	80.8 ^{ab} (73.9-88.4)	3.7 ^{ab} (3.2-4.1)	65.8 ^{ab} (59.8-72.0)	10.6 ^a (8.3-13.8)	13.3 ^a (10.9-16.4)
*Ethnicity						
White (n=236)	181.8 (174.5-188.3)	77.6 (70.1-86.0)	3.7 (3.2-4.2)	63.1 (57.0-69.5)	10.4 (7.9-13.6)	13.4 (11.0-16.4)
Black (n=97)	182.2 ^a (175.2-189.0)	82.6 ^a (74.9-90.9)	3.8 ^a (3.3-4.3)	67.6 ^a (61.1-74.7)	9.4 ^a (7.3-12.3)	11.6 ^a (9.4-14.3)
League						
Premier League (n=76)	182.7 (182.0-183.4)	78.9 (78.0-79.9)	3.8 (3.8-3.9)	64.6 (63.8-65.3)	9.7 (9.4-10.0)	12.4 (12.0-12.8)
Championship (n=234)	182.7 (182.0-183.4)	80.4 ^a (79.6-81.3)	3.8 (3.8-3.9)	65.3 (64.5-66.0)	10.5 ^a (10.2-10.8)	13.2 ^a (12.8-13.5)
League 1 (n=63)	181.9 (181.0-182.8)	80.0 (78.5-81.6)	3.8 (3.7-3.9)	65.1 (63.8-66.4)	10.6 ^a (10.0-11.2)	13.5 ^a (12.8-14.2)
League 2 (n=21)	181.9 (181.0-182.8)	81.0 ^a (79.2-82.9)	3.8 (3.7-3.9)	65.3 (63.7-66.9)	11.5 ^a (10.6-12.5)	14.3 ^a (13.3-15.4)
Time Point						
Pre-Season (n=239)	N/A	79.9 (78.8-81.0)	3.8 (3.7-3.9)	64.6 (63.9-65.4)	10.6 (10.1-11.3)	13.5 (12.9-14.1)
In-Season (n=189)		80.3 ^a (79.2-81.4)	3.8 (3.7-3.9)	65.5 ^a (64.7-66.2)	10.1 ^a (9.6-10.7)	12.8 ^a (12.2-13.3)
End-Season (n=111)		80.7 ^{ab} (79.6-81.8)	3.8 (3.8-3.9)	65.7 ^a (65.0-66.5)	10.2 ^a (9.7-10.8)	12.8 ^a (12.3-13.4)

a. Sig difference from GK; b. Sig difference from CD; c. Sig difference from WD; d. Sig difference from CM; e. Sig difference from WM; f. Sig difference from F ($p < 0.05$) a. Sig difference from white ($p < 0.05$) a. Sig difference from Premier League; b. Sig difference from Championship; c. Sig difference from League 1; d. Sig difference from League 2 ($p < 0.05$) a. Sig difference from Pre-Season; b. Sig difference from In-Season; c. Sig difference from End-Season ($p < 0.05$)

GK goalkeeper, CD central defender, WD wide defender, CM central midfielder, WM wide midfielder, F forward. Sig significant

* Other ethnicities not presented due to insufficient sample sizes for meaningful analysis

positions except goalkeepers ($p < 0.001$ – 0.004). Goalkeepers had significantly greater body fat percentage compared to all other positions (all: $p < 0.001$).

Anthropometric and body composition values by ethnicity

Anthropometrics

Black participants were significantly taller and heavier than white participants (both: $p < 0.001$).

Body composition

Black participants had significantly greater bone and fat-free soft tissue mass than white participants (both: $p < 0.001$). Black participants had significantly lower fat mass and body fat percentage than white participants (both: $p < 0.001$).

References in anthropometric and body composition values by league

Anthropometrics

Participants competing in the EPL had significantly lower body mass than participants competing in the EFL Championship or EFL Two (both: $p < 0.001$).

Body composition

Participants competing in the EPL had significantly lower fat mass and body fat percentage than participants competing in the EFL Championship, EFL One, and EFL Two ($p < 0.001$ – 0.050).

Differences in anthropometric and body composition values by season timepoint

Anthropometrics

Body mass was significantly greater in-season than pre-season ($p = 0.010$). Body mass was significantly greater at end-season than pre-season ($p < 0.001$) and in-season ($p = 0.020$).

Body composition

Fat-free soft tissue mass was significantly greater in-season and at end-season than pre-season (both: $p < 0.001$). Fat mass and body fat percentage was significantly lower in-season and at end-season than pre-season (both: $p < 0.001$).

Influence of age, league, ethnicity, playing position, and season phase

Following best-subset analysis, models were assessed against the four criteria established by Riley et al., [31] for appropriate multivariable prediction model development. All initial models demonstrated substantial overfitting, evidenced by large absolute differences between apparent and adjusted R^2 values (> 0.05). Despite systematic simplification of the models, no improvements in predictive performance were achieved, and acceptable

predictive models could not be identified. Consequently, the development of anthropometric and body composition prediction equations was not pursued further.

Discussion

Key findings

Mismanagement of body mass and composition in professional male football players is linked to adverse health and performance outcomes, highlighting the need for criterion-measured descriptive data to support improved practice. This study presents the most extensive dataset of criterion body composition values for professional male footballers, supporting evidence-based, athlete-centred decision-making. Findings revealed that percentage body fat ranged between 11.6% and 15.4% when categorised by playing position, ethnicity, and league, indicating that values above the often-cited $< 10\%$ threshold are regularly observed in elite male footballers. Additionally, specific anthropometric and body composition traits varied by position, ethnicity, and league, reinforcing the need for individualised rather than generic team-wide targets. Lastly, body composition improved throughout the season, with increases in fat-free soft tissue mass and reductions in fat mass, suggesting that moderate body mass increases across the season are likely beneficial adaptations rather than performance concerns.

The fat mass values reported in this study suggest that the often-reported $\sim 10\%$ body fat values for male professional footballers may not reflect the range observed in practice. Previous studies on EPL players have reported mean body fat percentages ranging from 10.0% to 11.2% across all positions [25, 30, 34], values which have likely contributed to the widespread perception that $\sim 10\%$ represents an appropriate or desirable target in elite male football. However, in the present study EPL players had a higher mean body fat percentage (12.4%: range: 12.0–12.8%) than previously reported, questioning the validity of the $\sim 10\%$ benchmark. Notably, EFL players had significantly higher body fat percentages than their EPL counterparts (EFL Championship: +0.8%; EFL One: +1.1%; EFL Two: +1.9% on average). This is the first study to report DXA-derived body composition values in the EFL, highlighting the importance of league-specific benchmarks. Unlike EPL players, EFL athletes often receive less support in areas such as nutrition, private and club food provision, and supplements, which may influence body composition outcomes [3]. While EPL targets may serve as useful reference for lower-league players, it is essential to consider their limited access to resources, particularly support from suitably qualified practitioners, when setting realistic and achievable goals that optimise both health and performance.

Our findings align with previous research suggesting distinct anthropometric and body composition

profiles for goalkeepers compared to outfield players [2, 23, 25, 34]. These physiological differences likely reflect the unique demands of the goalkeeper position, which requires greater height and, consequently, greater body mass to enhance reach, aerial dominance, and stability during explosive movements. Goalkeepers consistently demonstrate superior vertical jump performance compared to outfield players [40], and their increased fat-free soft tissue mass observed in this study may be a result of the greater strength and power needed for explosive actions such as diving, blocking, catching, and deflecting shots [28], alongside their overall greater body mass. Positional analysis also revealed distinct differences between central defenders, forwards, and other playing positions. Forwards and central defenders exhibited similar anthropometric and body composition profiles, likely due to the physical nature of their roles, which involve frequent body contact and explosive movements such as aerial duels and short sprints [4]. Meanwhile, central midfielders, wide midfielders, and wide defenders displayed comparable body composition profiles, potentially reflecting the aerobic demands of these positions, which require covering large distances (10–13 km per match) due to their involvement in both offensive and defensive play [9, 21].

Black participants in this study were taller, heavier, and had greater fat-free mass, yet lower fat mass and a lower percentage of body fat than White participants. This aligns with previous research suggesting that Black players typically exhibit higher bone mineral content and fat-free soft tissue mass than White individuals [37]. However, this contrasts with Sutton et al., [34], who found no significant differences in body mass or fat-free soft tissue mass percentage among 64 professional male EPL footballers, though they did report 1.5% lower body fat in non-Caucasian compared to Caucasian players. Collectively, these findings suggest that Black footballers may have greater fat-free mass and proportionally lower fat mass than White players. However, these studies are limited by the lack of further sub-classification of non-Caucasian groups (e.g., African vs. Asian) [34, 37]. Ethnic diversity in the present study was also limited, with only 2.9% (10/343) of participants classified as neither Black nor White. This may reflect the broader lack of ethnic diversity in English professional football, where only five British Asian players were registered to professional clubs in 2012 [17]. While there is increasing international representation in the English game (e.g., 62 nationalities in the 2024/25 EPL season), this does not necessarily equate to greater ethnic diversity, as squads may still be composed predominantly of Black and White players. This highlights a key gap in both research and practice: the need for descriptive body composition data across a

wider range of ethnicities to support more inclusive, individualised assessments and interventions.

To the authors' knowledge, this is the first study to examine seasonal body composition changes in professional male footballers across multiple English competitions over several seasons. Unlike single-club studies with fixed training loads and competition demands, this dataset offers broader insights into seasonal variations. The findings showed a significant reduction in body fat (-0.5 kg fat mass) from pre-season to in-season, aligning with Milanese et al., [24], who reported a ~10% decrease in fat mass in a sample of 31 Serie A footballers. Additionally, fat-free mass increased by 0.9 kg from pre-season to mid-season and 1.1 kg by end-season, supporting previous research [6, 24] that attributes these gains to consistent training stimuli and competitive match exposure. These findings challenge the perception that moderate in-season body mass increases should be viewed negatively by players, coaches, or performance staff, highlighting the importance of distinguishing between gains in fat-free soft tissue and fat mass before dictating body mass or composition adjustments. Rather than being a concern, such increases may indicate positive adaptations to training and match demands, potentially enhancing both player health and performance, and should not automatically raise concerns among coaches, managers, and wider performance and leadership staff (e.g., heads of performance and sporting directors), who are often responsible for interpreting and acting upon body composition data in applied settings, as is often the case.

Practical implications

This study provides the most extensive dataset of high-quality body composition measurements for English male professional football players to date. Ensuring player psychological well-being and physical health should remain a priority for practitioners. Our findings suggest that the ~10% body fat target commonly cited in previous small-sample studies and anecdotal reports may not accurately represent all professional male footballers, or that in-season small-to-moderate body mass increases are inherently negative. However, in the absence of direct performance or health outcome data, these observations should be interpreted with appropriate caution. Future work should examine how changes in body composition align with objective markers of health and performance to fully understand their impact in elite sport settings.

Importantly, setting unrealistic body fat percentage targets may contribute to negative body image or self-worth, resulting in problematic low energy availability, increasing the risk of REDs and/or disordered eating behaviours [29]. The body composition data presented in this study provides realistic, evidence-based reference ranges that consider key individual player characteristics,

including playing position, ethnicity, competition level, and seasonal timepoints. Overall, we hope the data will help inform position- and league-specific targets, track seasonal changes in body mass or composition, and support tailored return-to-play strategies — ultimately optimising player health and performance.

Strengths, limitations, and future research

This study offers several notable strengths. It provides criterion-standard body composition measurements from a substantial sample (>300) of professional male footballers competing across the top four tiers of English football. The dataset spans a decade, offering rare longitudinal insight and supporting evidence-based decision-making for practitioners seeking to optimise performance and safeguard player health.

However, certain limitations must be acknowledged. Data collection was undertaken by multiple operators over the 10-year period. Although all operators completed institutional training, inevitable changes in personnel and potential evolution of measurement protocols may have introduced minor variability in standardisation. Additionally, while the dataset is large for an elite sport cohort, the sample size was insufficient to robustly model continuous predictors such as age, where stable parameter estimation requires extensive representation across the full distribution. The dataset's observation density also limits the capacity for complex predictive modeling. Although this is the largest sample of its kind, it represents only ~2 teams per league. As such, the dataset should not be considered normative of all players within the English Premier or Football Leagues. A further limitation is that BMD values were derived from total body DXA composition scans rather than dedicated site-specific clinical scans; therefore, these values should be interpreted as descriptive comparative measures within this cohort rather than diagnostic assessments of bone health. Additionally, standardised effect sizes were not reported for between-group comparisons, which may have provided additional context regarding the magnitude and practical meaningfulness of observed differences. Finally, due to ethical constraints, club identifiers were not included in the dataset, which limited the ability to account for changes in league status over time (e.g., promotion or relegation). However, the use of player-level random effects partially addressed this by accounting for repeated measures across seasons, regardless of league transitions.

Future research should prioritise assembling larger, multi-centre datasets with comprehensive representation across age, playing position, and career stage to enable the development and external validation of predictive models. Equally, there is an urgent need for parallel research in elite female football to ensure that the health,

performance, and career longevity of female players receive the same level of scientific focus and evidence-based support as their male counterparts. Finally, future research should also investigate the relationship between changes in body composition and injury risk and availability in professional football, to better inform applied decision-making around player health and performance.

Conclusions

This is the first study to provide DXA-derived body composition measurements in male professional footballers across all tiers of English professional football. Significant differences were observed based on playing position, ethnicity, competition level, and seasonal timepoints. The values presented suggest that a uniform target of ~10% body fat may not be appropriate for all players, offering practitioners a valuable reference for monitoring and designing interventions using an individualised, athlete-centred approach to optimise player health and performance.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s44410-026-00028-8>.

Supplementary Material 1: Supplementary Table 1. Normative anthropometric variables per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 2. Normative bone mass values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 3. Normative bone mineral content values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 4. Normative bone mineral density values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 5. Normative fat-free mass values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 6. Normative fat-free soft tissue mass values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward. Supplementary Table 7. Normative fat mass values per position. GK, goalkeeper; CD, central defender; WD, wide defender; CM, central midfielder; WM, wide midfielder; F, forward.

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Code availability

The code used for data analysis is available upon reasonable request.

Disclosure statement

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Authors' contributions

Nessan Costello – Conceptualization, Data Curation, Investigation, Methodology, Supervision, Writing – Original Draft, Reviewing & Editing Cameron Owen – Formal Analysis, Resources, Writing – Original Draft, Reviewing & Editing Andrew Jenkinson, Ben Samuels, Albert Arrieta – Data Curation, Reviewing & Editing Matthew Barlow, Karen Hind, Marina Alexander, Ian Entwistle – Data Curation, Investigation, Methodology, Supervision, Reviewing & Editing Peter Francis, Mark Johnson, Gareth Jones – Supervision, Reviewing & Editing Stacey Emmonds, Paul Bower – Funding Acquisition, Supervision, Reviewing & Editing James Morton – Writing – Reviewing & Editing Ashley Jones – Conceptualization, Data Curation, Investigation, Methodology, Project Administration, Writing – Original Draft, Reviewing & Editing.

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Data availability

The data supporting this study's findings are available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Leeds Beckett University (application ref: 126825) in compliance with the Declaration of Helsinki and international research standards. Informed consent was obtained from all participants, including approval for secondary data analysis.

Competing interests

The authors declare no competing interests.

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