

Correlation between preseason body composition and sports injury in an English Premier League professional football team

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ABSTRACT

Objectives To identify the correlation between preseason body composition and incidence coupled with injury burden throughout the season in adult male professional football players.

Methods A retrospective case series was performed for linear regression analysis of preseason body composition variables and injury data. $R^2 > 0.10$ was deemed of adequate correlation.

Results All 36 professional football players in the male first team of an English Premier League professional football team were recruited, with none lost to follow-up. The total and mean incidence of injuries was 83.00 and 2.31 (95% CI 1.72 to 2.89), respectively. The mean injury burden was 58.32 (95% CI 37.67 to 78.98) days missed. Simple linear regression analysis indicated no significant or adequate correlations between incidence and preseason body composition variables. Injury burden revealed non-significant adequate negative correlations to body mass ($R^2=0.17$), body mass index (BMI) ($R^2=0.15$), waist circumference ($R^2=0.17$), total bone mineral density (BMD) ($R^2=0.11$) and mean embedded structures ($R^2=0.10$).

Conclusions Players with decreased body mass, BMI, waist circumference, total BMD and mean embedded structures may be prone to greater injury burden. Further studies with a larger sample size that incorporates multiple football teams are warranted to investigate this.

INTRODUCTION

Injuries are an inevitable drawback to any sport as they can be debilitating and costly.^{1,2} The prevention of injuries is an essential aspect in sport management to optimise team performance and resources. Preseason screening is commonly employed in sports to acquire a baseline measurement of individual health and fitness. It can be a measure of the players' ability to cope with the upcoming sporting season ahead and to allow rectification of substandard fitness levels but notably, to also allow detection of potentially new or monitoring of pre-existing medical abnormalities.

Preseason screening often includes, but has not been limited to, the measurement

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ To the authors' knowledge, youth football players with higher body mass index (BMI) and body mass have been associated with an increased incidence of injuries.

⇒ Body composition between youth and adult male football players is inherently different. Therefore, the association between higher BMI or body mass and increased incidence of injuries may not be applicable in adult elite football players.

WHAT THIS STUDY ADDS

⇒ Players with decreased body mass, BMI, waist circumference, total bone mineral density and mean embedded structures may have higher risk of injury.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ The findings of this study can allow clinicians to understand better the role of preseason body composition in adult male football players.

of body composition. Body composition can be measured by a vast array of methods but commonly with a stadiometer for height, weighing scale for body mass or dual-energy X-ray absorptiometry (DXA) for fat mass, lean mass, bone mineral content (BMC) and bone mineral density (BMD). Body composition within the normal limits can often be associated with good fitness on the preliminary level, but further tests remain critical to gauge the players' fitness level. Body composition has been long associated with football injuries.³⁻⁶ However, these studies have been limited to the adult female and youth football player, not the adult male football player. Increased body mass index (BMI) has been associated with an increased incidence of injuries in both the adult female (lower back and lower extremities)³ and youth football player.⁴⁻⁶

Furthermore, the body composition between youth and adult male football players has previously been reported to be different.⁷ Therefore, the association that increased



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BMI and increased incidence of injuries may not apply to adult male football players as observed in youth football players. The purpose of the study was to identify the correlation between preseason body composition and incidence coupled with injury burden throughout the season in adult male football players. The findings of this study can allow clinicians to understand better the role of preseason body composition in adult male football players. This can enable the optimisation of body composition accordingly to better prepare players for the upcoming season.

METHODS

Study design, eligibility criteria and data extraction

A retrospective case series was performed for linear regression analysis. All players listed in the first team of an English Premier League professional football team were eligible for inclusion. No exclusion criteria were present. Verbal informed consent was obtained from all players. Data were extracted from a secure, centralised database of players' clinical records that contains all preseason body composition and injury data. These data have been consistently documented at the time of preseason screening and injury event only by team physicians and coaches. Injury data extracted for linear regression analysis were twofold: incidence (n) and injury burden (days missed). The preseason body composition data extracted were fourfold:

1. Player demographics: population (n), sex and age.
2. Anthropometric measurements: height, leg length, body mass, BMI, waist circumference, hip circumference and thigh circumference.
3. DXA measurements: total area, total BMC, fat mass, lean mass, total mass, total per cent fat, subtotal BMD and total BMD.
4. Ultrasound subcutaneous adipose tissue (SAT) measurements: mean embedded structures, lateral thigh mean embedded structure, lateral thigh area embedded structure, anterior thigh mean embedded structure, anterior thigh area embedded structure, calf mean embedded structure and calf area embedded structure.

DXA scan

The DXA scan (Discovery W Bone Densitometer, Hologic, Ontario, Canada) was performed by a fully trained independent operator with specialisation in body composition measurements and multiple years of experience. Players were placed in the supine position for an automatic whole-body scan. All scans were performed between 7 July 2017 and 8 July 2017.

Ultrasound SAT scan

Ultrasound SAT measurements have demonstrated high reliability and accuracy in groups ranging from lean to obese.⁸ The same fully trained independent operator performed the ultrasound SAT measurements. Eight ultrasound sites for SAT measurements were present

and were all marked with the patient standing. These markings have been detailed in a previous study.⁹ Ultrasound SAT measurements were performed with the players placed lying in supine, prone or rotated position. Ultrasound images were processed to determine SAT thickness using a Fat Analysis Tool software (V.3.1, Rotosport, Stategg, Austria). Despite eight ultrasound sites being measured for SAT thickness, only measurements at the lateral thigh, anterior thigh and calf were extracted for linear regression analysis as injury data documented were predominantly of lower limb injuries.

Definition of an 'injury'

An injury was defined as: 'tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy'.^{10 11} All injuries were extracted from medical records and required medical attention.

Definition of 'incidence of injuries' and 'injury burden'

The incidence of injuries was defined as: the total number of injuries sustained (n). Injury burden was defined as: the total number of days missed through injuries (days missed).

Mean embedded structures

Mean embedded structures refers to an ultrasound SAT measurement that is the mean of the SAT thickness at the ultrasound sites of the upper abdomen, lower abdomen, erector spinae, distal triceps, brachioradialis, lateral thigh, anterior thigh and medial calf.

Statistical analysis

All statistical analysis was performed using R V.3.5.1 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were calculated for all continuous and categorical variables. Continuous variables were reported as mean with CIs. CIs were calculated using the methods described by Bulpitt.¹² Categorical variables were reported as frequencies with percentages. Simple linear regression was performed for injury data with the following preseason body composition data: (1) anthropometric measurements, (2) DXA measurements and (3) ultrasound SAT measurements. Multiple linear regression was performed for variables identified of adequate correlation with interactions accounted for. Two summary statistics were employed to assess the adequacy of the linear regression: (1) R^2 value, (2) F-statistic with the corresponding p value. Multiple R^2 values were employed to assess simple linear regression models and adjusted R^2 values to assess multiple linear regression models. An $R^2 > 0.10$ was deemed of adequate correlation.¹³ The partial F-test was employed to test if a variable can be removed from the multiple linear regression model without making the model significantly worse (comparison of nested models). Statistical significance was accepted for $p < 0.05$.

RESULTS

Player demographics

All 36 professional football players in a single English Premier League male first team were recruited in July 2016. Injury data were documented over the course of the whole sporting season from August 2016 to May 2017 (9 months), with no players lost to follow-up. The mean age was 23.92 (95% CI 22.54 to 25.29). Total and mean incidence of injuries was 83 and 2.31 (95% CI 1.72 to 2.89), respectively. The mean injury burden was 58.32 (95% CI 37.67 to 78.98) days missed. The positional breakdown of the players were: 6 goalkeepers, 11

defenders, 12 midfielders and 7 forwards. A descriptive statistics summary of the preseason body composition and injury data are illustrated in [table 1](#).

Simple linear regression analysis

Simple linear regression analysis indicated no significant or adequate correlations between incidence and preseason body composition variables. Simple linear regression analysis of injury burden to preseason body composition data indicated adequate correlations to (1) body mass ($R^2=0.17$, $p=0.06$), (2) BMI ($R^2=0.15$, $p=0.08$), (3) waist circumference ($R^2=0.17$, $p=0.06$), (4) total BMD

Table 1 Preseason body composition and injury data (all subjects were male)

Player demographics and injury data	
Population (n)	36
Mean age (years)	23.92 (22.54 to 25.29)
Total incidence of injuries (n)	83
Mean incidence of injuries (n)	2.31 (1.72 to 2.89)
Mean injury burden (days missed)	58.32 (37.67 to 78.98)
Follow-up (months)	9
Anthropometric measurements	
Mean height (m)	1.82 (1.80 to 1.85)
Mean leg length (m)	1.02 (1.01 to 1.04)
Mean body mass (kg)	78.30 (75.63 to 80.97)
Mean BMI (kg/m ²)	23.52 (23.09 to 23.94)
Mean waist circumference (m)	0.78 (0.77 to 0.79)
Mean hip circumference (m)	0.95 (0.94 to 0.96)
Mean thigh circumference (m)	0.53 (0.52 to 0.53)
DXA measurements	
Mean total area (cm ²)	2479.13 (2428.08 to 2530.18)
Mean total BMC (g)	3619.29 (3498.03 to 3740.56)
Mean fat mass (g)	10354.39 (9622.46 to 11086.31)
Mean lean mass (g)	65420.20 (63510.69 to 67329.70)
Mean lean mass +BMC (g)	68726.21 (66672.87 to 70779.55)
Mean total mass (g)	79080.61 (76727.87 to 81433.35)
Mean total per cent fat (%)	13.06 (12.31 to 13.82)
Mean subtotal BMD (g/cm ²)	1.35 (1.32 to 1.37)
Mean total BMD (g/cm ²)	1.46 (1.43 to 1.48)
Ultrasound SAT measurements	
Mean of mean embedded structures* (mm)	0.55 (0.46 to 0.63)
Mean of lateral thigh mean embedded structure (mm)	0.55 (0.38 to 0.73)
Mean of lateral thigh area embedded structure (mm ²)	6.95 (4.75 to 9.15)
Mean of anterior thigh mean embedded structure (mm)	0.48 (0.31 to 0.65)
Mean of anterior thigh area embedded structure (mm ²)	6.59 (4.34 to 8.85)
Mean of calf mean embedded structure (mm)	0.18 (0.10 to 0.26)
Mean of calf area embedded structure (mm ²)	2.20 (1.22 to 3.19)
.BMC, bone mineral content; BMD, bone mineral density; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; SAT, subcutaneous adipose tissue .	

($R^2=0.11$, $p=0.15$) and (5) mean embedded structures ($R^2=0.10$, $p=0.15$). All linear regression lines revealed a negative correlation. Furthermore, these adequate correlations were all statistically non-significant. A simple linear regression summary is illustrated in [table 2](#).

Multiple linear regression analysis

Multiple linear regression analysis indicated that the injury burden was best correlated with (1) BMI and (2) waist circumference ($R^2=0.16$, $p=0.11$). The partial F-test revealed that the addition of mean embedded structures to the model was non-significant ($p=0.15$). Injury burden was also observed to be adequately correlated with (1) body mass and (3) waist circumference ($R^2=0.11$, $p=0.16$) with the addition of mean embedded structure to this model similarly non-significant as per the partial F-test ($p=0.19$). A multiple linear regression summary is illustrated in [table 3](#).

DISCUSSION

The linear regression analysis revealed no statistically significant correlations between incidence or injury burden and the preseason body composition variables analysed. As the included player group were highly heterogeneous in body composition and of low sample size, it is not surprising that there was no significant correlation between the various preseason body composition measures and sports injury. However, this data remains valuable to demonstrate this in adult elite football players (although small sample size) that has otherwise been limited. The DEXA scan is considered the most accurate measure of body composition.¹⁴ It measures total area, total BMC, fat mass, lean mass, total mass, total per cent fat, subtotal BMD and total BMD, and the results of this study showed no significant correlation with injury burden. However, injury burden revealed non-significant adequate negative correlations ($R^2 > 0.10$) to five preseason body composition variables: body mass, BMI, waist circumference, total BMD and mean embedded structures. Multiple linear regression analysis indicated that injury burden was best correlated with both BMI and waist circumference. This finding was also non-significant. Although these correlations were all statistically non-significant, it is noteworthy that the current study was of a small sample size and limited data points. Therefore, further studies are warranted to validate these correlative findings at the statistical level with studies of larger sample sizes that incorporates multiple football teams and a greater number of data points.

It is important to emphasise that the principal findings are not reflective of the general population as the sample size was distinctly adult male professional football players. The findings revealed here are interesting as it contrasted to the findings of other populations that higher BMI has been associated with an increased incidence of injuries in notably the adult female (lower back and lower extremities)³ and youth football player.⁴⁻⁶ The reason for these findings has been uncertain. The linear

Table 2 Simple linear regression summary

	Multiple R^2	P value
Basic measurements		
Incidence of injuries (n)		
Height (m)	<0.01	0.94
Leg length (m)	<0.01	0.81
Body mass (kg)	0.01	0.56
BMI (kg/m^2)	0.04	0.30
Waist circumference (m)	0.03	0.35
Hip circumference (m)	0.09	0.13
Thigh circumference (m)	0.03	0.35
Injury burden (days missed)		
Height (m)	0.08	0.19
Leg length (m)	0.02	0.56
Body mass (kg)	0.17	0.06
BMI (kg/m^2)	0.15	0.08
Waist circumference (m)	0.17	0.06
Hip circumference (m)	0.08	0.19
Thigh circumference (m)	0.08	0.20
DXA measurements		
Incidence of injuries (n)		
Total area (cm^2)	<0.01	0.75
Total BMC (g)	0.02	0.51
Fat mass (g)	<0.01	0.86
Lean mass (g)	<0.01	0.81
Lean mass +BMC (g)	0.01	0.56
Total mass (g)	0.01	0.57
Total per cent fat (%)	<0.01	0.86
Subtotal BMD (g/cm^2)	0.03	0.39
Total BMD (g/cm^2)	0.03	0.39
Injury burden (days missed)		
Total area (cm^2)	0.05	0.37
Total BMC (g)	0.09	0.20
Fat mass (g)	0.05	0.37
Lean mass (g)	0.03	0.48
Lean mass +BMC (g)	0.03	0.46
Total mass (g)	0.05	0.34
Total per cent fat (%)	0.02	0.52
Subtotal BMD (g/cm^2)	0.06	0.32
Total BMD (g/cm^2)	0.11	0.15
Ultrasound SAT measurements		
Incidence of injuries (n)		
Mean embedded structures* (mm)	<0.01	1.00
Lateral thigh mean embedded structure (mm)	0.04	0.30

Continued

Table 2 Continued

	Multiple R ²	P value
Lateral thigh area embedded structure (mm ²)	0.03	0.37
Anterior thigh mean embedded structure (mm)	0.03	0.43
Anterior thigh area embedded structure (mm ²)	0.04	0.34
Calf mean embedded structure (mm)	<0.01	0.72
Calf area embedded structure (mm ²)	0.01	0.61
Injury burden (days missed)		
Mean embedded structures* (mm)	0.10	0.15
Lateral thigh mean embedded structure (mm)	<0.01	0.71
Lateral thigh area embedded structure (mm ²)	<0.01	0.94
Anterior thigh mean embedded structure (mm)	<0.01	0.84
Anterior thigh area embedded structure (mm ²)	<0.01	0.83
Calf mean embedded structure (mm)	0.04	0.36
Calf area embedded structure (mm ²)	0.04	0.37

.Bold = R²>0.10BMC, bone mineral content; BMD, bone mineral density; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; SAT, subcutaneous adipose tissue .

regression analysis revealed no correlations between the incidence of injuries and BMI or body mass in adult male professional football players. However, an increased body mass, BMI, waist circumference, total BMD and mean embedded structures may be a protective factor for injury burden based on the adequate correlation revealed by

the linear regression analysis (although arguably statistically non-significant). The increased durability of bones with a higher BMD may translate into a lower injury burden, including a lower risk of fractures.¹⁵ These findings must only be interpreted to a certain extent, as the sample size did not include players of the extreme high or low body composition. Therefore, it must be noted that the findings of the current study do not demonstrate that an extreme increase or decrease in body mass, BMI, waist circumference, total BMD and mean embedded structures are correlated with a decreased or increased injury burden, respectively.

In this study of adult professional football players, it was notable that only 2 of the 36 players recruited were of ≥ 25 BMI. Therefore, the ability for further analysis of how incidence or injury burden is correlated with various subgroups of body composition variables was limited. For example, in the subgroups of underweight, normal, overweight and obese BMI. Theoretically, it appears sound that there would be a specific BMI threshold of the linear regression model performed. To conceptualise that the higher the BMI, the lower the injury burden even at the extreme end is far-fetched. Grant *et al* demonstrated in 132 injuries of 55 male collegiate hockey players that players with BMI ≥ 25 kg/m² had a greater 2.1 times odds of injury compared with players of BMI < 25 kg/m².¹⁶ Sugimoto *et al* demonstrated in 160 youth female football players that prior musculoskeletal injuries were similarly correlated with higher weight and BMI.⁴ Venturelli *et al* further demonstrated in 84 youth male football players that elevated stature increased the probability of thigh strain.⁵ In the military population, Nye *et al* indicated that the effect of obesity on injury risk is greatest in the 25–34-year-old participants and that there appears to be a dose-response relationship between obesity and musculoskeletal injury risk.¹⁷

Contrastingly, Ezzat *et al* demonstrated in a cross-sectional study of 12 407 12–19 year-old that no significant association was found between being overweight and sports injury, but a protective effect was seen between

Table 3 Multiple linear regression summary

	Adjusted R ²	P value	Partial F-test
Injury days missed ~			
Body mass +waist circumference +body mass:waist circumference	0.11	0.16	0.19
Body mass +waist circumference +body mass:waist circumference +mean embedded structures	0.15	0.15	
BMI +waist circumference +BMI:waist circumference	0.16	0.11	0.15
BMI +waist circumference +BMI:waist circumference +mean embedded structures	0.22	0.09	

BMI, body mass index; NA, not applicable; Bold = R²>0.10.



obesity and sports injury instead.¹⁸ In a systematic review of sport climbing and bouldering by Woolings *et al*, higher BMI was reported to be associated with a higher risk of injury in one of the included studies but not found in two of the other included studies.¹⁹ The current literature has revealed conflicting data of how body composition is correlated with sporting injuries in and within various populations. What is theoretically and evidentially more certain is that the adult body composition is different from the youth body composition.⁷ This study is essential in preliminarily identifying the correlation between preseason body composition and injuries throughout the season in adult male professional football players.

The findings of this study suggest that players of decreased body mass, BMI, waist circumference, total BMD and mean embedded structures should focus on increasing these variables during the preseason (not excessively) or have personalised training tailored as an injury prevention regime. Taylor *et al* demonstrated in a systematic review and meta-analysis of lower extremity injury prevention in basketball that injury prevention regimes significantly reduced the incidence of general lower extremity injuries and ankle sprains but not anterior cruciate ligament ruptures.²⁰ Sadisgursky *et al* similarly demonstrated in a systematic review that an injury prevention regime such as the FIFA 11+ has been effective in the prevention of injuries.²¹ These injury prevention regimes should perhaps be strongly implemented for players of decreased body mass, BMI, waist circumference, total BMD and mean embedded structures in the preseason, considering the notable findings of the current study.

Limitations

There were several limitations to this study. Data were retrospectively extracted, and clinical record-keeping quality was dependent on the clinicians and coaches with the database access. The study was of a small sample size with players that were recruited from a single team. Therefore, the study sample size may not accurately represent all adult male professional football players or the general population. Body composition measurements may have been measured more often throughout the season to provide regularly updated data points and provide further data on changes from the pre-season baseline. This could have accounted for the possibility of deconditioning over the close season. The use of ultrasound, although performed by a single fully trained operator, could be dependent on operator proficiency.²² The force of contact injuries sustained was unable to be quantified. Stronger forces experienced may have an increased susceptibility to injury resulting in confounding bias. The strength of the study was that no players were lost to follow-up and this, minimised selection bias.

CONCLUSION

This is the first study that has identified the correlation between preseason body composition and incidence,

coupled with injury burden throughout the season in adult male professional football players. Simple linear regression analysis indicated no significant or adequate correlations between incidence and preseason body composition variables. However, injury burden was revealed to have non-significant adequate negative correlations to five preseason body composition variables: body mass, BMI, waist circumference, total BMD and mean embedded structures. Players with decreased body mass, BMI, waist circumference, total BMD and mean embedded structures may be prone to greater injury burden (although arguably statistically non-significant). Further studies with a larger sample size that incorporates multiple football teams are warranted to better investigate the correlation of the various body composition measurements with the incidence and injury burden; also if there is a prime method of body composition assessment.

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Data availability statement Data are available upon reasonable request.

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