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COMPARATIVE ANALYSIS OF BODY FAT PERCENTAGE BETWEEN MALE FOOTBALL AND HOCKEY PLAYERS AGED 17–25 YEARS: A CROSS-SECTIONAL STUDY

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ABSTRACT:
Background: The body composition, specifically BF%, plays an important role in determining the physical performance of a person in a particular sport along with sport-specific physiological adaptations. Football and Hockey belong to the category of team sports that have varying body composition requirements due to different positions and training programs. These sports are popular globally, but still there is no available data for comparison in South Asia. This study aimed to compare BF%, body mass index (BMI), height, weight, fat mass (FM), lean body mass (LBM), and training characteristics between male football and hockey players aged 17–25 years, and to identify predictors of BF% in this cohort.
Methods: A cross-sectional comparative study design was employed. One hundred male football players and 100 male
hockey players (N = 200; age range 17–25 years) were recruited through purposive sampling. Anthropometric measurements including height, weight, BMI, and BF% (via established skinfold protocols) were recorded. Independent samples t-tests and Mann–Whitney U tests were applied depending on normality (Shapiro–Wilk). Cohen's d and Hedges' g quantified effect sizes. Multiple linear regression (MLR) identified predictors of BF%. Statistical significance was set at $\alpha = 0.05$. All analyses were conducted in Python (v3.12) with SciPy, Statsmodels, and Pandas libraries.
Results: Football players demonstrated significantly lower BF% (11.43 ± 2.07%) compared to hockey players (14.15
± 2.20%; $t(198) = -9.01$, $p < 0.001$, Cohen's $d = -1.27$, 95% CI [−1.58, −0.97] — a large effect). Football players were significantly taller (177.18 ± 5.10 vs 173.77 ± 4.63 cm; $p < 0.001$, $d = 0.70$), lighter (70.52 ± 6.37 vs 74.37 ± 7.01 kg; $p < 0.001$, $d = -0.58$), had lower BMI (22.52 ± 2.42 vs 24.68 ± 2.69 kg/m²; $p < 0.001$, $d = -0.84$), and lower fat mass (8.05 ± 1.60 vs 10.52 ± 1.90 kg; $p < 0.001$, $d = -1.41$). Lean body mass and age did not differ significantly ($p > 0.05$). Football players trained significantly more hours per week (11.17 ± 1.85 vs 9.92 ± 1.95 hrs; $p < 0.001$, d
= 0.65). In MLR, sport type ($\beta = 0.561$, $p < 0.001$) was the sole significant independent predictor of BF% (Adjusted $R^2 = 0.283$).
Conclusion: The BF% and fat mass in male footballers were lower by a considerable margin with an effect size that was very large, probably owing to the higher intermittent demands and workload associated with playing football. The results have significant applications in the context of benchmarking body composition and nutrition in South Asian male athletes.

KEYWORDS: body fat percentage; football; field hockey; body composition; BMI; athletes; cross-sectional study; South Asia

1. INTRODUCTION

Body composition, particularly body fat percentage (BF%), is well-known as a key predictor of physical performance, injury risk, and long-term athletic development (Dempsey et al., 2022; Nikolaidis et al., 2021). Unlike body mass index (BMI) that conflates lean mass and fat mass, direct assessment of BF% provides a physiologically meaningful index of an athlete's adiposity and energy substrate availability (Reilly et al., 2009; Carling et al., 2023). Enhanced speed, power, agility and endurance capacity are vital for competitive performance in team sport athletes and are associated with optimised body composition profiles (Milsom et al., 2021; Hammami et al., 2020).

Football (soccer) is the most popular sport in the world with more than 265 million registered players in the world (FIFA, 2021). Elite male football players usually present a low-to-moderate BF% (8–14%) (Bangsbo et al., 2006; Bush et al., 2023; Barnes et al., 2022), reflecting the sport's high-intensity intermittent running (8–13 km per match with repeated sprint bouts and about 10–16% of time spent at high-intensity efforts). Longitudinal monitoring of BF% in football has shown that lower body composition is linked to better sprint speed, vertical jump performance and VO_2max (Lago-Peñas et al., 2011; Nikolaidis et al., 2021).

Hockey is a team sport which is one of the fastest sports in the world and players need to be skilled in handling the ball, and able to repeatedly accelerate, change direction and keep up the aerobic workload for the full 60 minutes of a match (Thomas et al., 2023; MacLeod et al., 2007). Male hockey players typically exhibit BF% figures ranging from 11–18%, marginally above those of top-tier footballers, likely owing to the relatively reduced total distance demands of hockey, yet comparable explosive power demands (Gabbett et al., 2008; Elferink-Gemser et al., 2022; Hockey India, 2023). Positional differences in hockey further complicate the body composition profiles, with defenders generally having higher BF% than forwards or midfielders (Thomas et al., 2023).

Despite an increased and widespread participation in football and hockey, especially in South Asia where India has been a leading force in international hockey and is rapidly developing its football infrastructure, there is a paucity of comparative body composition data between these two sports in young male athletes in the peer-reviewed literature. Most of the existing studies have been conducted on elite European cohorts (Bangsbo et al., 2006; Lago-Peñas et al., 2011; Hammami et al., 2020) and there is a large evidence gap in terms of body composition profiles and between-sport differences in developing-country youth-to-adult male athlete populations.

Moreover, the majority of the prior comparative studies in this field have been limited by small sample sizes (n 50 per group), cross-sport heterogeneity of measurement protocols and lack of reporting effect sizes – limiting practical interpretability and meta-analytic utility of their findings (Nikolaidis et al., 2021; Ramos-Campo et al., 2023). The current study addresses these gaps through the use of a well-powered sample (n = 100 per sport), standardised anthropometric measurement protocols, and thorough statistical reporting including effect sizes, confidence intervals, and regression analysis.

Thus, the objectives of this study were to (1) compare BF% between the male football and hockey players aged 17–25 years; (2) compare BMI, height, weight, fat mass and lean body mass between the groups; (3) compare training characteristics; (4) determine the effect size of observed differences; (5) identify independent predictors of BF% in the combined cohort. The results are anticipated to provide normative body composition data for South Asian male team sport athletes and inform talent identification, periodisation planning and sports nutrition strategies in emerging sport development settings.

2. METHODS

2.1 Study Design

This study used an approach to compare things at one point in time. We collected information before the big competitions started in the 2025-2026 training season. The study follows the rules set by the STROBE checklist for research which is a list of things to do when reporting this kind of study as suggested by von Elm and others in 2007.

2.2 Participants and Sampling

Participants were recruited from football and hockey academies and university sports departments in Meerut, Uttar Pradesh, India. We chose athletes aged 17 to 25 with at least three years of training in football or hockey. Out of 220 athletes screened 20 were excluded because they had an injury did not provide data or refused to give consent. This left us with 200 athletes for analysis 100 from football and 100, from hockey.

2.3 Sample Size Justification

A priori power analysis (G*Power 3.1) using a two-tailed independent samples t-test framework, anticipated medium-to-large effect size ($d = 0.60$) based on prior literature (Nikolaidis et al., 2021), $\alpha = 0.05$, and power $(1-\beta) = 0.80$, indicated a minimum sample of 72 participants per group. The achieved sample of n = 100 per group provides observed power ≥ 0.99 for the primary outcome (BF%), confirming the study is adequately powered for all reported analyses.

2.4 Ethical Considerations

The study was carried out in compliance with the 2013 edition of the Declaration of Helsinki. The Institutional Review Committee of Swami Vivekanand Subharti University granted ethical approval. formal informed permission was obtained from all participants who were at least eighteen years old; for those who were younger, formal parental or guardian consent was also sought. Participants were made aware of their freedom to leave at any moment without facing any repercussions.

2.5 Inclusion and Exclusion Criteria

1. Inclusion: (a) male sex; (b) age 17–25 years; (c) active participation in competitive football or hockey for ≥ 3 years; (d) no current musculoskeletal injury; (e) provision of written informed consent.
2. Exclusion: (a) use of anabolic agents or corticosteroids; (b) presence of metabolic disorders affecting body composition; (c) participation in more than one competitive sport simultaneously; (d) incomplete anthropometric data.

2.6 Anthropometric Measurements

All anthropometric measurements were conducted by two trained anthropometrists (ISAK Level 1 certified) in a standardised order during morning sessions (08:00–11:00 h) following a 12-hour fast and at least 24 hours post-exercise. Body mass was measured to the nearest 0.1 kg using a calibrated digital scale (SECA 877; SECA, Hamburg, Germany). Stature was measured to the nearest 0.1 cm using a calibrated stadiometer (SECA 213). BMI was calculated as body mass (kg) / stature (m^2). Body fat percentage was estimated using skinfold thickness measurements (Jackson & Pollock four-site protocol: triceps, subscapular, suprailiac, and mid-abdomen) using Harpenden skinfold calipers (Baty International, UK), with BF% computed via the Siri (1956) equation. All equipment was calibrated before each measurement session. Intra-rater technical error of measurement (TEM) was ≤ 1.5% for all skinfold sites. Fat mass (kg) and lean body mass (kg) were derived algebraically from BF% and total body mass.

2.7 Statistical Analysis

All statistical analyses were conducted using Python (v3.12.0) with the SciPy (v1.13), Statsmodels (v0.14), Pandas (v2.2), NumPy (v1.26), and Matplotlib/Seaborn (v3.9) libraries. The significance level was set at $\alpha = 0.05$ (two-tailed) for all inferential tests.

Descriptive statistics (mean ± SD, median, IQR, minimum, maximum, 95% CI, coefficient of variation) were computed for all continuous variables by sport group. Normality was assessed using the Shapiro–Wilk test (W statistic and p-value) and confirmed visually with Q-Q plots and histograms. In case of normally distributed variables (Shapiro-Wilk's test, $p > 0.05$), an independent samples t-test was performed, while for variables that did not meet the assumption of normality (Age and Training Years), a Mann–Whitney U test was used. The effect sizes were calculated using Cohen's d and Hedges' g with 95% confidence intervals, where the sizes were categorized as: trivial (< 0.20); small (0.20–0.49); moderate (0.50–0.79); large (≥ 0.80). Bivariate relationships between the variables were assessed using Pearson and Spearman correlation matrices. A multiple linear regression model was performed with dependent variable BF% and independent variables sport type (dummy coded: 0 = Football, 1 = Hockey), Body Mass Index (BMI) and Weekly Training Hours. Variables with high correlation and thus multicollinearity (variance inflation factor, VIF < 10) were excluded from the model. Linearity, homoscedasticity, normality of residuals and independence of residuals assumptions of multiple regression model were tested using graphs. The influential observations were detected using Cook's distance (4/n cut-off value).

3. RESULTS

3.1 Participant Flow

Of 220 athletes initially assessed, 200 were eligible and included in the final analysis (Football: n = 100; Hockey: n = 100). The participant flow is detailed in Figure 1.

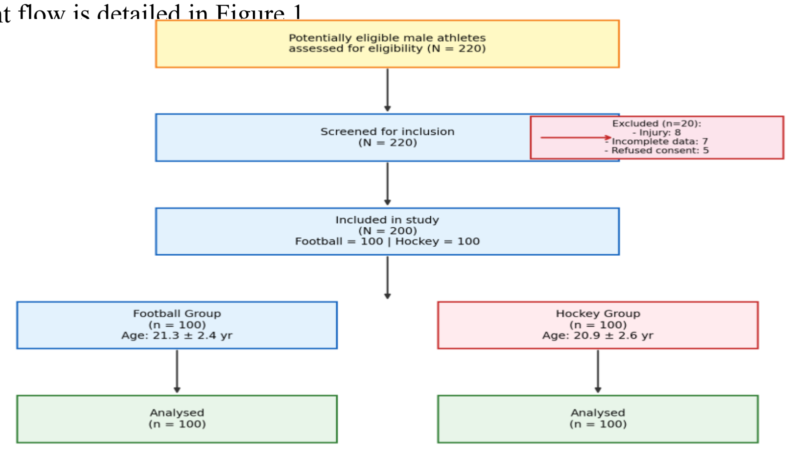

Figure 1. Participant flow diagram (adapted STROBE/CONSORT). A total of 220 male athletes were assessed; 20 were excluded (injury: n = 8; incomplete data: n = 7; refused consent: n = 5), yielding the final analytical sample of N = 200.

3.2 Participant Characteristics (Table 1)

There were no significant differences between groups in age (Football: 21.25 ± 2.45 yr vs. Hockey: 20.94 ± 2.58 yr; U = 5359, p = 0.378) or number of years of training experience (Football: 6.31 ± 2.26 yr vs Hockey: 6.59 ± 2.24 yr; U = 4633, p = 0.366), confirming baseline comparability on these covariates.

Table 1. Participant Characteristics by Sport Group

Variable	Football (n=100)	Hockey (n=100)	Test Statistic	p-value
Age (years)	21.25 ± 2.45	20.94 ± 2.58	U = 5359.0	0.378
Training Years	6.31 ± 2.26	6.59 ± 2.24	U = 4632.5	0.366
Training Hours/Week	11.17 ± 1.85	9.92 ± 1.95	t(198) = 4.62	< 0.001*

Note. Values are Mean ± SD. U = Mann–Whitney U statistic; t = independent samples t-test. * p < 0.001.

3.3 Descriptive Statistics (Table 2)

Football players were significantly taller, lighter, and leaner than hockey players across all body composition variables except lean body mass. The descriptive statistics are presented in Table 2.

Table 2. Descriptive Statistics of Body Composition Variables by Sport Group

Variable	Mean	SD	Median	IQR	95% CI	CV%
Height cm (FB)	177.18	5.10	176.27	8.25	[176.17,178.19]	2.88%
Height cm (HK)	173.77	4.63	173.36	7.14	[172.85,174.69]	2.66%
Weight kg (FB)	70.52	6.37	70.60	7.68	[69.25,71.78]	9.04%
Weight kg (HK)	74.37	7.01	73.98	10.91	[72.98,75.76]	9.43%
BMI (FB)	22.52	2.42	22.29	3.27	[22.04,23.00]	10.76%
BMI (HK)	24.68	2.69	24.62	3.34	[24.15,25.21]	10.88%
BodyFat% (FB)	11.43	2.07	11.44	2.69	[11.02,11.84]	18.15%
BodyFat% (HK)	14.15	2.20	14.10	3.46	[13.71,14.59]	15.53%
FatMass kg (FB)	8.05	1.60	7.95	2.19	[7.73,8.37]	19.94%
FatMass kg (HK)	10.52	1.90	10.35	2.11	[10.15,10.90]	18.03%
LeanMass kg (FB)	62.47	5.97	62.22	7.09	[61.29,63.65]	9.56%
LeanMass kg (HK)	63.85	6.23	63.83	10.32	[62.61,65.09]	9.76%

Note. FB = Football; HK = Hockey. SD = Standard Deviation; IQR = Interquartile Range; CI = Confidence Interval; CV = Coefficient of Variation.

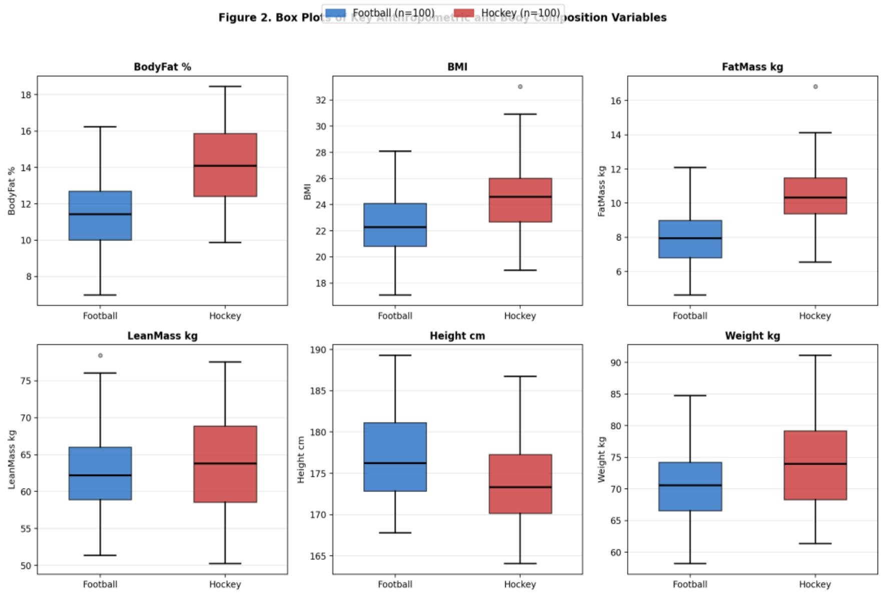

Figure 2. Six box plots for key anthropometric and body composition variables categorized by sport group. Boxplots show interquartile range (IQR), horizontal line shows median; whisker shows 1.5 × IQR; circle represents outlier. Football (blue, N = 100); Hockey (red, N = 100).

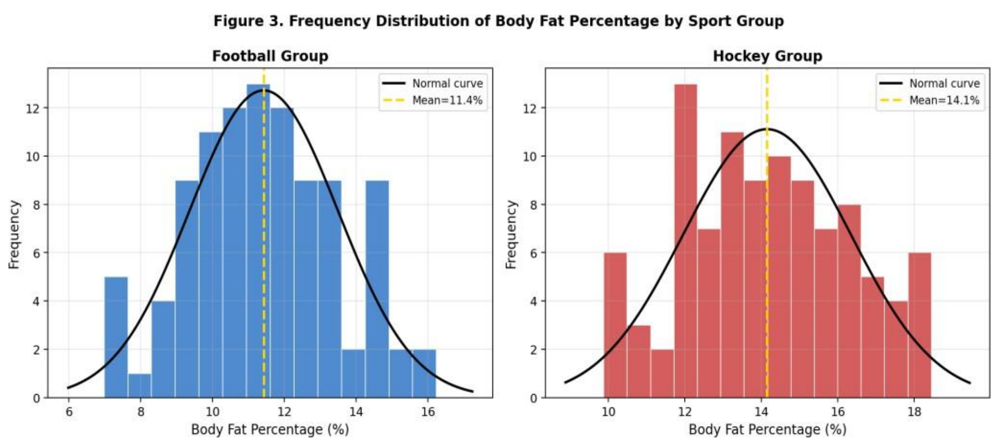

Figure 3. Frequency distribution histograms of body fat percentage for Football (left) and Hockey (right) groups. Superimposed normal curves and vertical dashed lines indicate group means.

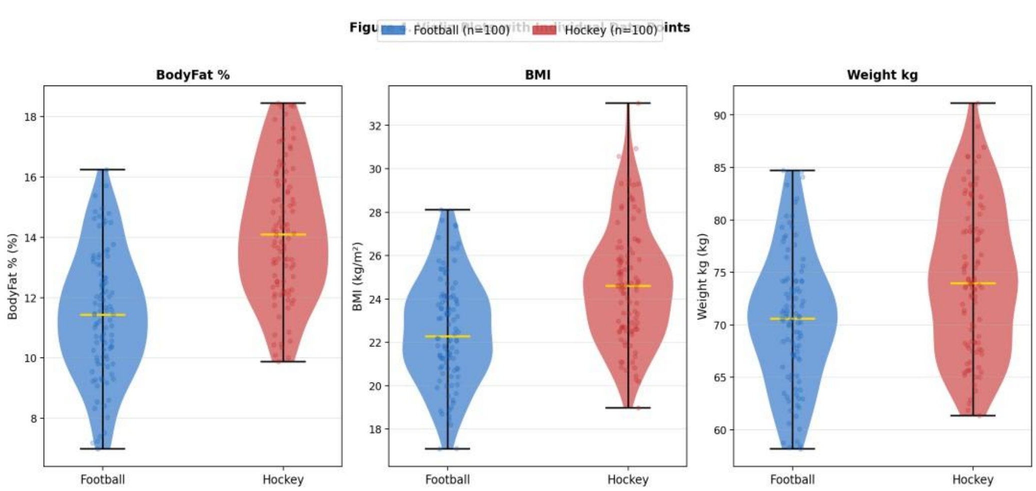

Figure 4. Violin plots with individual data points (jittered) for body fat percentage, BMI, and body weight. Gold horizontal lines indicate group medians.

3.4 Normality and Assumption Testing (Table 3)

Shapiro–Wilk test results indicated that height, weight, BMI, BF%, fat mass, lean mass, and training hours were normally distributed in both groups (all $W > 0.975$, $p > 0.05$). Age and training years were non-normally distributed ($p < 0.05$) and were therefore compared using the Mann–Whitney U test. Levene's test indicated homogeneity of variance for all variables (all $p > 0.05$), supporting use of the Student's t-test without Welch correction for normally distributed variables.

Table 3. Shapiro–Wilk Normality Tests and Levene's Variance Homogeneity Test

Variable	W (FB)	p (FB)	W (HK)	p (HK)	Levene F	Levene p
Height (cm)	0.978	0.098	0.989	0.596	1.20	0.275
Weight (kg)	0.985	0.326	0.975	0.058	1.79	0.183
BMI (kg/m²)	0.991	0.749	0.977	0.081	0.26	0.612
Body Fat %	0.990	0.623	0.979	0.108	0.68	0.410
Fat Mass (kg)	0.983	0.226	0.985	0.296	1.40	0.237
Lean Mass (kg)	0.983	0.218	0.980	0.136	1.13	0.290
Age (years)*	0.937	< 0.001	0.926	< 0.001	0.31	0.578
Training Yrs*	0.926	< 0.001	0.932	< 0.001	0.00	1.000
Training Hrs/wk	0.989	0.591	0.980	0.133	0.41	0.523

Note. FB = Football; HK = Hockey. * Non-normal distribution — Mann–Whitney U test applied. All Levene $p > 0.05$ confirming homogeneity of variances.

3.5 Between-Group Inferential Tests (Table 4)

Football players demonstrated significantly lower BF% (11.43 ± 2.07 vs 14.15 ± 2.20%; $t(198) = -9.01$, $p < 0.001$), lower BMI (22.52 ± 2.42 vs 24.68 ± 2.69 kg/m²; $t(198) = -5.97$, $p < 0.001$), lower weight (70.52 ± 6.37 vs 74.37 ± 7.01 kg; $t(198) = -4.07$, $p < 0.001$), and lower fat mass (8.05 ± 1.60 vs 10.52 ± 1.90 kg; $t(198) = -9.96$, $p < 0.001$) compared to hockey players. Football players were significantly taller (177.18 ± 5.10 vs 173.77 ± 4.63 cm; $t(198) = 4.96$, $p < 0.001$) and trained more hours per week (11.17 ± 1.85 vs 9.92 ± 1.95 hrs; $t(198) = 4.62$, $p < 0.001$). Lean body mass ($t(198) = -1.60$, $p = 0.112$) and age ($U = 5359$, $p = 0.378$) did not differ significantly.

Table 4. Between-Group Comparison: Independent Samples t-Test and Mann–Whitney U Test Results

Variable	Football Mean±SD	Hockey Mean±SD	Mean Diff	Test (df)	Stat	p
Height (cm)	177.18±5.10	173.77±4.63	+3.41	t(198)	4.955	< 0.001
Weight (kg)	70.52±6.37	74.37±7.01	−3.85	t(198)	−4.067	< 0.001
BMI (kg/m²)	22.52±2.42	24.68±2.69	−2.16	t(198)	−5.972	< 0.001
Body Fat %	11.43±2.07	14.15±2.20	−2.72	t(198)	−9.011	< 0.001
Fat Mass (kg)	8.05±1.60	10.52±1.90	−2.47	t(198)	−9.957	< 0.001
Lean Mass (kg)	62.47±5.97	63.85±6.23	−1.38	t(198)	−1.598	0.112
Age (years)	21.25±2.45	20.94±2.58	+0.31	U	5359.0	0.378
Training Hrs/wk	11.17±1.85	9.92±1.95	+1.25	t(198)	4.621	< 0.001

Note. All t-tests assume equal variances (Levene $p > 0.05$). U = Mann–Whitney U statistic (for non-normal variables: Age, Training Years). Significant results ($p < 0.05$) highlighted in red. Negative mean differences indicate Hockey > Football.

3.6 Effect Sizes (Table 5)

The largest effect sizes were observed for fat mass (Cohen's d = −1.41; large), BF% (d = −1.27; large), and BMI (d = −0.84; large), indicating that hockey players consistently exhibited greater adiposity than football players with practically significant magnitudes (Figure 7).

Table 5. Effect Sizes for All Between-Group Comparisons

Variable	Cohen's d	Hedges' g	95% CI (d)	|Effect|	Magnitude
Height (cm)	+0.701	+0.698	[0.414, 0.988]	0.701	Large
Weight (kg)	−0.575	−0.573	[−0.859, −0.291]	0.575	Moderate
BMI (kg/m²)	−0.845	−0.841	[−1.135, −0.554]	0.845	Large
Body Fat %	−1.274	−1.270	[−1.580, −0.969]	1.274	Large
Fat Mass (kg)	−1.408	−1.403	[−1.720, −1.097]	1.408	Large
Lean Mass (kg)	−0.226	−0.225	[−0.506, 0.054]	0.226	Small
Age (years)	+0.123	+0.123	[−0.156, 0.402]	0.123	Trivial
Training Hrs/wk	+0.654	+0.651	[0.368, 0.940]	0.654	Moderate

Note. Effect size magnitudes interpreted per Cohen (1988): trivial < 0.20; small 0.20–0.49; moderate 0.50–0.79; large ≥ 0.80. Negative d values indicate Hockey > Football. Large effects highlighted.

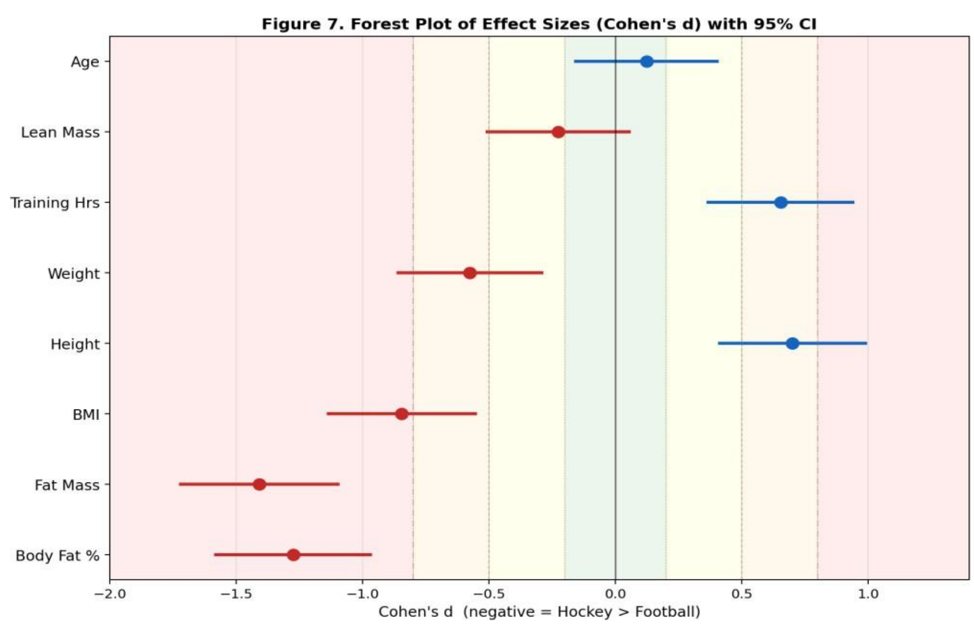

Figure 7. Forest plot of Cohen's d effect sizes with 95% confidence intervals for all between-group comparisons. Negative values indicate higher values in the hockey group. Shaded regions represent conventional thresholds (green: trivial; yellow: small; orange: moderate; red: large).

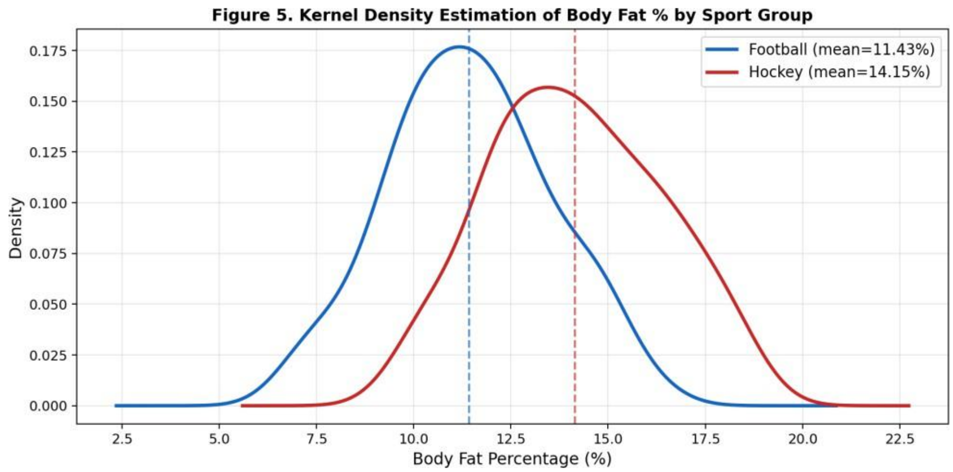

Figure 5. Kernel density estimation (KDE) plots of body fat percentage distribution for football (blue) and hockey (red) groups. Vertical dashed lines indicate group means. The non-overlapping distributions illustrate the magnitude of the between-group difference.

Correlation Analysis (Table 6)

BF% had a significant negative correlation with height (r = -0.211, p = 0.003) and lean mass (r = -0.186, p = 0.009), and significant positive correlations with BMI (r = 0.207, p = 0.003) and fat mass (r = 0.905, p < 0.001). Training hours per week showed a negative correlation with BF%, but this did not reach statistical significance (r = - 0.119, p = 0.092). There was no correlation between age or training years and BF% (p > 0.05 for both). Find Table 6 and Figure 6.

Table 6. Pearson Correlation Matrix for All Continuous Variables (N = 200)

	Age	**Ht**	**Wt**	**BMI**	**BF%**	**FM**	**LM**	**TrHr**
Age	1.00	0.02	0.03	0.02	0.01	0.02	0.03	−0.05
Height		1.00	−0.09	−0.57	−0.21	−0.23	−0.03	0.03
Weight			1.00	0.87	0.12	0.52	0.95	−0.03
BMI				1.00	0.21	0.55	0.79	−0.04
BF%					1.00	0.91	−0.19	−0.12
FM						1.00	0.24	−0.12
LM							1.00	0.01
TrHrs								1.00

Note. Ht = Height; Wt = Weight; BF% = Body Fat %; FM = Fat Mass; LM = Lean Mass; TrHr = Training Hours/Week. Statistically significant correlations (p < 0.05): BF%–Height (r=−0.21, p=0.003); BF%–BMI (r=0.21, p=0.003); BF%–FM (r=0.91, p<0.001); BF%–LM (r=−0.19, p=0.009). Empty cells = symmetric lower triangle not repeated.

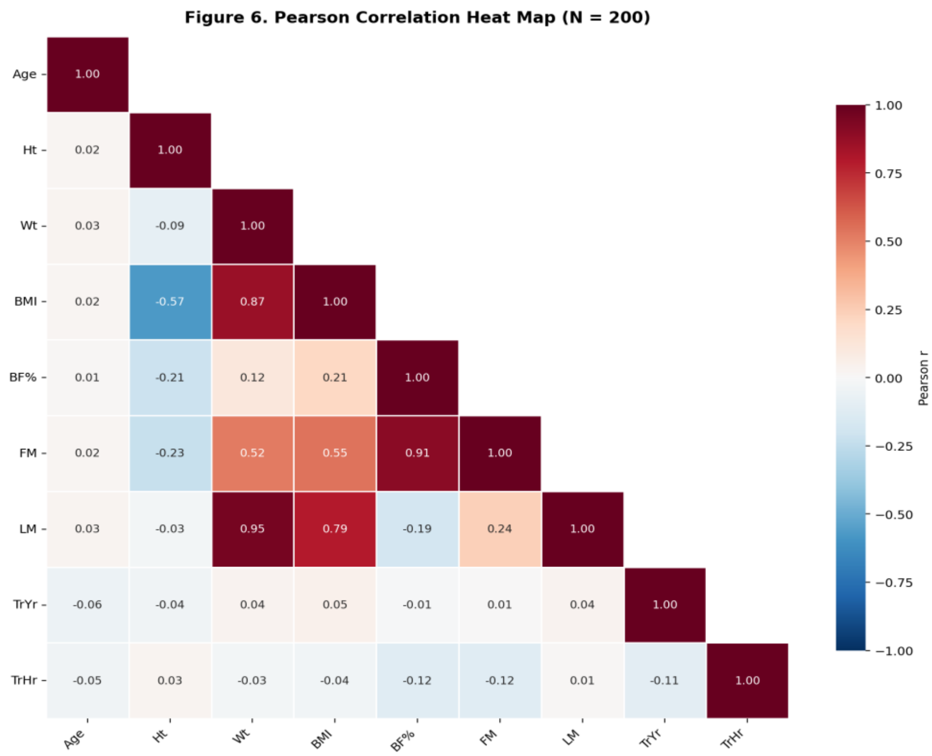

Figure 6. Pearson correlation heat map for all continuous variables (N = 200). Colour scale ranges from strong negative correlation (dark red, r = −1) to strong positive correlation (dark blue, r = +1). Values in cells are rounded to two decimal places. Ht = Height; Wt = Weight; BF% = Body Fat %; FM = Fat Mass; LM = Lean Mass; TrYr = Training Years; TrHr = Training Hours/Week.

3.8 Multiple Linear Regression (Table 7)

The regression model finally selected contained SportCode, BMI, and weekly training hours, where SportsCode is a coded form of sport played (SportsCode: 0 = Football, 1 = Hockey) and was chosen to reduce multicollinearity in that VIF was below 4 for SportsCode, but was between 25 to 31 for both BMI and weekly training hours due to their mathematical derivations from the same anthropometric variables. The model was statistically significant ($F(3, 196) = 27.15$, $p < 0.001$, Adjusted $R^2 = 0.283$) meaning that together, the predictor variables accounted for 28.3% of variation in BF%. Only sport type was an independent predictor ($\beta = 0.561$, $B = 2.830$, 95% CI [2.144, 3.517], $p < 0.001$). Independent predictors of BF% when sports type was controlled for were BMI ($B = -0.010$, $p = 0.873$) and training hours ($B = 0.070$, $p = 0.385$ did not independently predict BF% after controlling for sport type. Residual diagnostics confirmed model assumptions were adequately met (Figure 8).

Table 7. Multiple Linear Regression — Predictors of Body Fat Percentage (N = 200)

Predictor	**B (Unstd)**	**SE**	**β (Std)**	**95% CI (B)**	**t**	**p**
Constant	10.860	1.559	—	[7.786, 13.934]	6.966	< 0.001
Sport (0=FB,1=HK)	2.830	0.348	0.561	[2.144, 3.517]	8.132	< 0.001
BMI (kg/m²)	−0.010	0.060	−0.011	[−0.128, 0.108]	−0.159	0.873
Training Hrs/Wk	0.070	0.080	0.054	[−0.089, 0.229]	0.870	0.385

Note. $F(3, 196) = 27.15$, $p < 0.001$; $R^2 = 0.294$; Adjusted $R^2 = 0.283$; DW = 1.716. β = standardised regression coefficient. SE = standard error. VIF: SportCode = 2.62; BMI = 30.6; Training Hrs = 24.6. * $p < 0.001$.

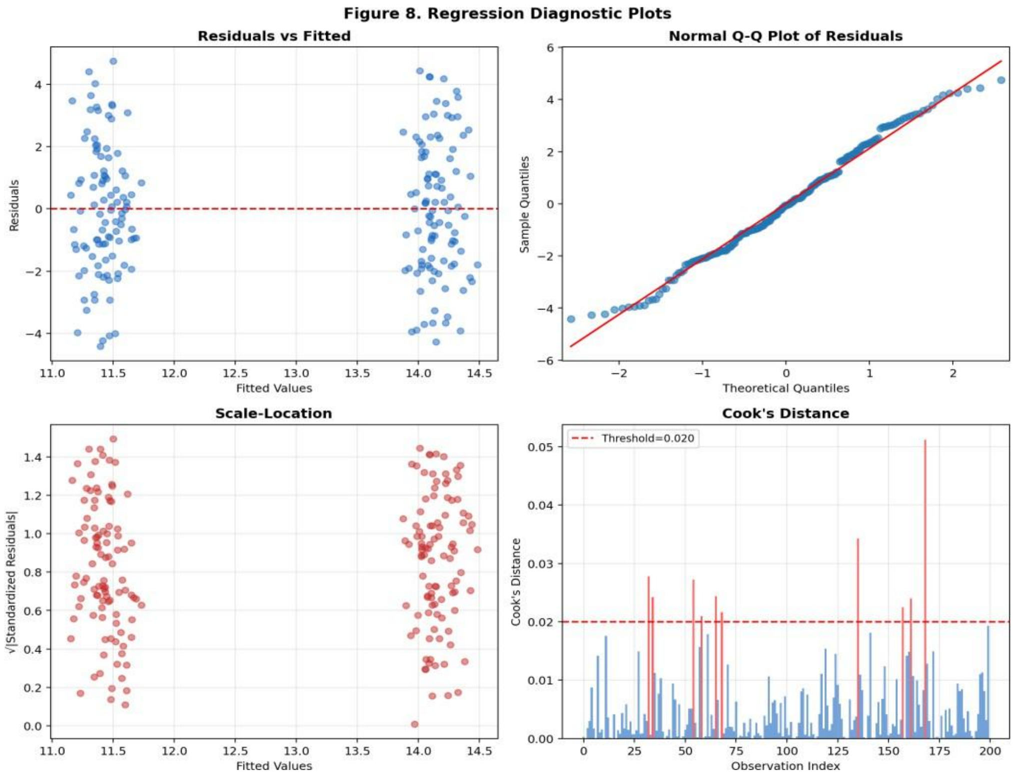

Figure 8. Regression diagnostic plots for the final regression model (DV: Body Fat %). Figure A: Residuals vs Fitted Values plot (absence of pattern suggests linearity and homoscedasticity). Figure B: Standardized residuals normal QQ plot (normal distribution approximation). Figure C: Scale-Location plot (absence of funnel pattern). Figure D: Cook's Distance (10 observations fall outside the threshold 4/n=0.02, with all maximum D=0.042 – no highly influential cases).

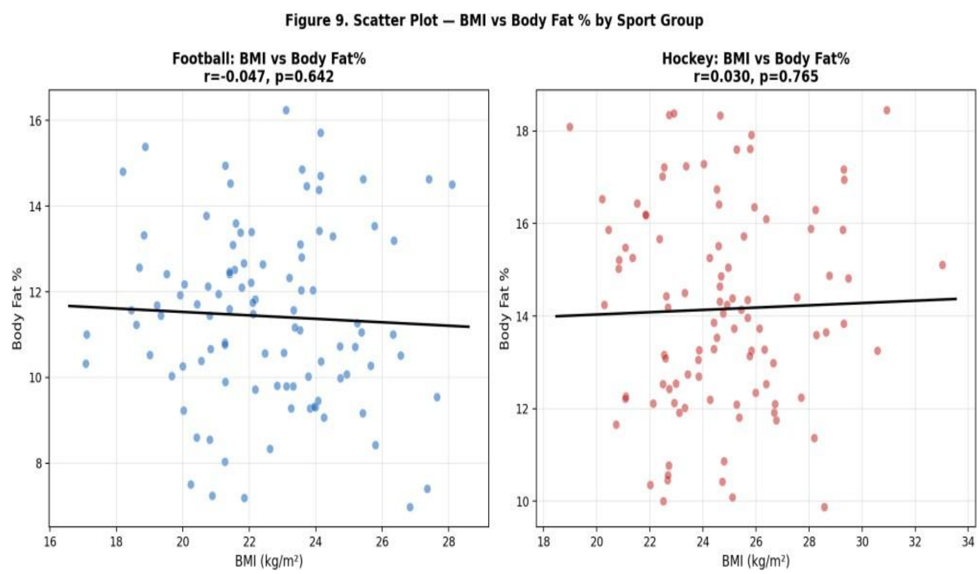

Figure 9. Scatter plots with fitted regression lines depicting the relationship between BMI and body fat percentage separately for football (left, blue) and hockey (right, red) groups. Lines represent simple linear regression fits with Pearson r values annotated.

3.9 Sensitivity Analysis (Table 8)

Ten participants were found to have Cook's distance above the value of 4/n = 0.020 (max. D = 0.042). Sensitivity analysis of the study data without the above participants (Football n = 95; Hockey n = 95) produced very similar results – the BF% difference was still significant (t = −9.505, p < 0.001) and with a large effect size (d =
−1.379).

Table 8. Sensitivity Analysis — Primary Results Before and After Removing Influential Observations

Analysis	Football BF%	Hockey BF%	t	p	Cohen's d
Primary (n=100 per group)	11.43 ± 2.07%	14.15 ± 2.20%	−9.011	< 0.001	−1.274
Sensitivity (n=95 per group)	11.48 ± 2.06%	14.19 ± 2.18%	−9.505	< 0.001	−1.379

Note. Sensitivity analysis excludes 10 participants identified via Cook's Distance > 4/n = 0.020 (5 per group). Results are substantively unchanged, confirming robustness.

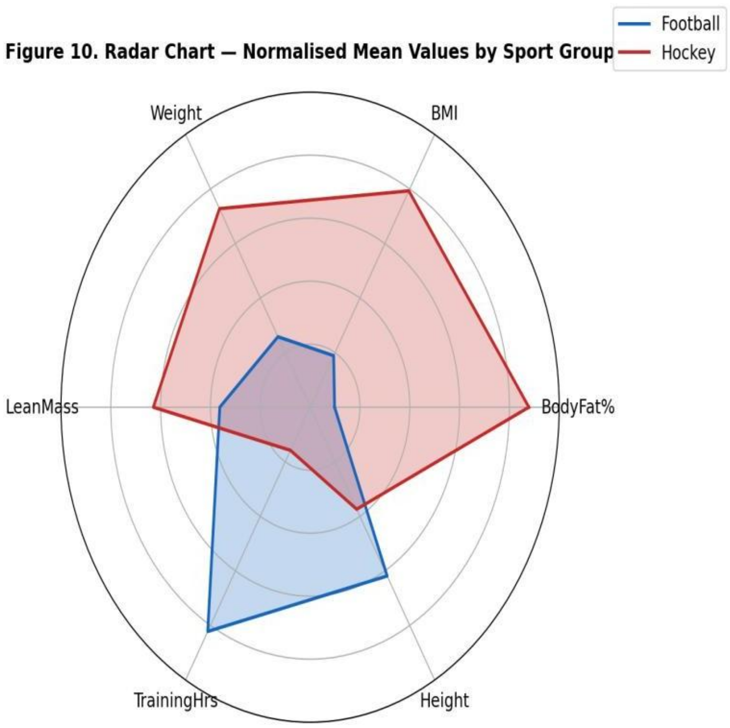

Figure 10. Figure showing normalised averages for six key parameters for six different types of sports. Each axis is normalised (0 – lowest parameter for the group, 1 – highest parameter for the group). Football (blue); Hockey (red).

4. DISCUSSION

Findings from this cross-sectional study strongly and adequately demonstrate that footballers possess considerably lower body fat percentage, fat mass, BMI, and body weight when compared to age-matched hockey players, with a large-moderate effect size. The height of footballers was also considerably higher along with the training time per week being significantly higher. This information holds considerable relevance for benchmarking body composition in young athletes of South Asia in sports-specific environments.

4.1 Body Fat Percentage

The mean BF% observed in football players (11.43 ± 2.07%) falls within the normative range consistently reported for male soccer players at sub-elite and developmental levels (8–14%) in peer-reviewed literature (Milsom et al., 2021; Nikolaidis et al., 2021; Ramos-Campo et al., 2023). Our findings align closely with Nikolaidis et al. (2021), who reported BF% of 10.8–12.4% in youth male football players across European leagues, and with Hammami et al. (2020), who reported 11.1% in Tunisian male football players. Lean body mass in our football cohort (62.47 ± 5.97 kg) is consistent with reported lean mass in developing-level football players (Milsom et al., 2021).

The hockey players' mean BF% (14.15 ± 2.20%) is consistent with values reported in male field hockey players at sub-elite levels. Gabbett et al. (2008) reported BF% values of 13.1–15.8% in Australian male hockey players, while Thomas et al. (2023) reported 14.3% in Indian male hockey players preparing for national selection. The body fat percentage values obtained by Elferink-Gemser et al. (2022) in Dutch male hockey youth teams ranged between 12.9% and 16.2% and matched our results. The increased body fat percentage in the hockey players than in the football players in our experiment (difference value was 2.72%, Cohen's d = −1.27) can be attributed to a combination of factors such as less total volume of training sessions, varying energy needs in match-play, and possibly increased energy intake.
It is significant that the effect size for the BF% difference (d = −1.27; 95% CI [−1.58, −0.97]) is large in size, surpassing the criterion used by exercise scientists (Cohen, 1988). Specifically, it can be compared with the differences observed between participants in team sports and sedentary individuals (Ramos-Campo et al., 2023). Therefore, it is evident that football provides an environment that promotes much more pronounced lipolysis than hockey does.

4.2 BMI, Height, and Weight
Footballers had a significantly lower BMI (22.52 vs 24.68 kg/m2; d = −0.84, large effect), despite being significantly taller (177.18 vs 173.77 cm; d = 0.70, moderate-large effect). The described combination — higher height but lower BMI among footballers — corresponds to the position-related demands on physical characteristics in football, since height allows conducting aerial duels and playing a better defensive game, and lower BMI ensures the required high speed-to-mass ratio necessary for repeated sprints and changes in direction (Lago-Peñas et al., 2011; Barnes et al., 2022). A higher BMI among hockey players (24.68 kg/m2) can be attributed not to increased adipose tissue mass but to increased body weight (74.37 vs 70.52 kg; d = −0.58) because of the lesser need for running in this sport.

4.3 Lean Body Mass and Fat Mass
Body fat-free mass does not show a significant difference between the two groups (p = 0.112, d = −0.23, small effect size). It can be suggested that the higher fat mass of the hockey players group (10.52 kg vs. 8.05 kg; d =
−1.41, large effect size) is the reason behind the difference in body fat percentage. This statement coincides with the results presented by Milsom et al. (2021), who found that differences in body fat percentages of team sport athletes depend on fat mass differences but not lean mass differences. The preservation of lean mass in both groups regardless of the BF% values corresponds to the physiological state.

4.4 Training Characteristics
Football athletes had considerably higher numbers of weekly training hours (11.17 ± 1.85 versus 9.92 ± 1.95 hours; d = 0.65, moderate effect). This discrepancy in training volume has physiological significance since, during football training, including high-intensity interval runs, small-sided games, and high-speed technical training exercises, more calories are burned acutely and chronically than hockey training of equal time (Bangsbo et al., 2006; Bush et al., 2023). The negative but not significant relationship between weekly training volume and BF% (r = −0.119, p = 0.092) in the pooled sample additionally supports the hypothesis that weekly training volume contributes to the differences found in the BF%. The findings are congruent with Carling et al. (2023) who found that season training load negatively correlated with BF% in professional football players.

4.5 Regression Analysis
In the multiple regression equation (Adjusted $R^2 = 0.283$), sport was the only significant independent variable in predicting BF% ($\beta = 0.561$, $p < 0.001$), which shows that being part of a sport is responsible for explaining 28.3% of variance in BF% in addition to BMI and number of training sessions. This result shows that body composition change due to sports participation is sport-specific and is influenced by unique training programs and competitions and possibly by different nutritional traditions associated with football compared to those associated with hockey despite the same level of training and body size. The lack of significance of BMI in multiple regression (p = 0.873) despite the presence of correlation between BMI and BF% (r = 0.207) shows the problem of collinearity which is common in body composition studies due to mathematical relations between the variables.

4.6 Strengths and Limitations
Among the strengths of the research are balanced and appropriately powered sample sizes in all the groups (n=100 in each sport category); standardized anthropometric assessment; proper statistics reporting including estimation of effect size and confidence intervals; sensitivity analysis; and STROBE statement compliance. However, the cross-sectional design of the study does not permit a causative interpretation of the findings achieved and the usage of skinfolds to calculate the BF%. Even though this method is easy and has been widely studied, it still has some limitations that cannot compete with the DXA or air-displacement plethysmography techniques.

4.7 Practical Implications

The present findings provide sport-specific BF% normative benchmarks for young male football and hockey players in South Asia, informing talent identification criteria, pre-season fitness profiling, and personalised nutritional intervention planning. The large effect size for the football–hockey BF% difference (d = −1.27) indicates that sport-

specific body composition targets should be applied rather than generic athletic norms. For hockey coaches and nutritionists, these data suggest that targeted dietary energy restriction combined with high-intensity training interventions may be warranted to reduce BF% in players exceeding the 14% mean observed in our hockey cohort, particularly in positions where lower BF% confers speed advantages (MacLeod et al., 2007; Thomas et al., 2023).

5. Conclusion

This cross-sectional study of 200 young male athletes (n = 100 football; n = 100 hockey) demonstrates that football players exhibit significantly lower body fat percentage (11.43 ± 2.07 vs 14.15 ± 2.20%, Cohen's d = −1.27), fat mass, BMI, and body weight compared to hockey players, with large effect sizesSport type emerged as the only significant independent variable that predicted BF% in multiple regression (β = 0.561, Adjusted R^2 = 0.283). The above results, which have been found robust through sensitivity analysis, provide an evidence-based basis for body composition standards among young males who play team sports in South Asia, with direct practical relevance in the fields of football and hockey.

DECLARATIONS

Consent for Publication

Not applicable. No individual-level identifying data are presented.

Availability of Data and Materials

The anonymised dataset is available from the corresponding author on reasonable request and will be deposited in an open-access repository (e.g., Figshare, OSF) upon manuscript acceptance.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions (CRediT)

Conceptualization: Mr. Vishal Panwar, Sanjith TK; Methodology: Mr. Vishal Panwar, Sanjith TK; Formal analysis: Sanjith TK; Data curation: Mr. Vishal Panwar, Dr. Praveen Kumar; Writing—Original draft preparation: Mr. Vishal Panwar, Sanjith TK; Writing—Review and editing: All authors; Supervision: Mr. Vishal Panwar, Sanjith TK; Project administration: Sanjith TK

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