RESEARCH ARTICLE

INTERNATIONAL JOURNAL OF KINANTHROPOMETRY

DOI: 10.34256/ijk25118

Position-Specific Anthropometric Characteristics and Body Composition of Female Field Hockey Players

Ekta Kapri [1,*], Subrata Dey [2], Manju Mehta [1], Kiran Singh [1], Keren Harish Tiwari [3], Erika Zemková [4]

[1] Department of Family Resource Management, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India
[2] Ergonomics and Sports Physiology Laboratory, Faculty of Health and Wellness, Sri Sri University, Cuttack, Odisha, India
[3] Department of Sports Physiology and Nutrition, National Sports University (A Central University), Imphal, Manipur, India
[4] Department of Biological and Medical Sciences, Faculty of Physical Education and Sport, Comenius University, Bratislava, Slovakia.
* Corresponding author email: kapriekta70@gmail.com

DOI: https://doi.org/10.34256/ijk25118
Received: 31-10-2024; Revised: 03-04-2025; Accepted: 15-04-2025; Published: 25-04-2025

Abstract

Introduction: This study aimed to examine the anthropometric characteristics, body composition, and somatotypes of female field hockey players. **Methods:** The study involved 30 female athletes aged ranges 13-21 years from the Giri Center in Hisar, Haryana. The anthropometric measurements were conducted in accordance with the protocols of the International Society for the Advancement of Kinanthropometry (ISAK). Bioelectrical impedance analysis (BIA) was employed to assess body composition, while somatotype was determined using the Heath-Carter method. Data were analyzed using descriptive statistics, correlation analysis, and somatotype indices to explore positional differences. **Results:** Results showed significant differences in physical attributes based on player positions. The study found significant correlations between height and lean body mass ($r=0.639$, $p\leq0.05$), indicating the influence of height on muscle development. The anthropometric analysis showed that goalkeepers had notably higher skinfold measurements, signifying greater subcutaneous fat levels, corresponding to lower aerobic demands. Conversely, forwards exhibited substantially lower fat percentage (18.48±3.23%) and higher lean body mass (41.85±4.45 kg), emphasizing their requirement for agility and speed. Goalkeepers showed significantly higher mean shoulder breadth (40.51±1.81 cm, $p\leq0.0001$) and knee height (51.56±2.10 cm, $p\leq0.0001$). Additionally, somatotype analysis revealed that most players were classified as ectomorphic-endomorphs (mean indices of 4.47-1.95-3.31), with fullbacks displaying higher mesomorphy (mean 2.82). **Conclusions:** These findings emphasize the need for tailored training programs specific to player positions to optimize performance, reduce injury risks, and enhance team effectiveness.

Keywords: Sports performance, Body fat percentage, Somatotype, Physical fitness, Bioelectrical impedance analysis, Correlation

Resumen

Introducción: Este estudio tuvo como objetivo examinar las características antropométricas, la composición corporal y los somatotipos de jugadoras de hockey sobre césped. **Métodos:** El estudio involucró a 30 atletas femeninas de entre 13 y 21 años del Centro Giri en Hisar, Haryana. Las mediciones antropométricas se realizaron de acuerdo con los protocolos de la Sociedad Internacional para el Avance de la Cineantropometría (ISAK). El análisis de impedancia bioeléctrica (BIA) se empleó para evaluar la composición corporal, mientras que el somatotipo se determinó utilizando el método de Heath-Carter. Los datos se analizaron utilizando estadística descriptiva, análisis de correlación e índices de somatotipo para explorar las diferencias posicionales. **Resultados:** Los resultados mostraron diferencias significativas en los atributos físicos basados en las posiciones de los jugadores. El estudio encontró correlaciones significativas entre la altura y la masa corporal magra ($r = 0,639$, $p \leq 0,05$), lo que indica la influencia de la altura en el desarrollo muscular. El análisis antropométrico mostró que las porteras tenían mediciones de pliegues cutáneos notablemente más altas, lo que significa mayores niveles de grasa subcutánea, lo que corresponde a menores demandas aeróbicas. Por el contrario, los delanteros mostraron

un porcentaje de grasa corporal sustancialmente menor (18,48 ± 3,23 %) y una mayor masa muscular magra (41,85 ± 4,45 kg), lo que pone de relieve su necesidad de agilidad y velocidad. Los porteros mostraron una media de anchura de hombros (40,51 ± 1,81 cm, p ≤ 0,0001) y una altura de rodilla (51,56 ± 2,10 cm, p ≤ 0,0001) significativamente mayores. Además, el análisis del somatotipo reveló que la mayoría de los jugadores se clasificaron como ectomorfos-endomorfos (índices medios de 4,47-1,95-3,31), mientras que los laterales mostraron una mayor mesomorfia (media de 2,82). **Conclusiones:** Estos hallazgos subrayan la necesidad de programas de entrenamiento específicos para cada posición de jugador para optimizar el rendimiento, reducir el riesgo de lesiones y mejorar la eficacia del equipo.

Palabras Clave: Rendimiento deportivo, Porcentaje de grasa corporal, Somatotipo, Aptitud física, Análisis de impedancia bioeléctrica, Correlación

Introduction

The determinants of athletic excellence encompass a complex matrix of morphological and anthropometric factors that extend beyond technical proficiency. Research in sports science has increasingly emphasized the role of morphological and anthropometric characteristics in optimizing athletic performance (Singh et al., 2010). The well-established relation between physical activity, fitness parameters, and health outcomes provides a theoretical background for analyzing these components within field-based athletic training protocols. Field hockey, in particular, presents a distinctive framework for examining these relationships, as it demands athletic abilities, cognitive capabilities, and exceptional reaction time (McGuigan et al., 2013). Recent research recognized that specific physique attributes characterize an athlete's physical development and significantly influence physical fitness and sports performance. The complex relationship between sports-specific demands and physical characteristics encompasses anthropometric dimensions and somatotype classification. A thorough investigation is necessary to quantify the correlation between these variables and performance outcomes.

Within this context of morphological influence on athletic performance, anthropometry is a crucial methodological framework for analyzing physical characteristics, providing valuable insights into specific physical attributes that optimize performance across different competition levels. Recent analyses have demonstrated a significant correlation between anthropometric parameters and sports-specific performance metrics, particularly in field-based sports (Keogh, López-Fernández et al., 2020). Notably, in field hockey, this relationship becomes especially significant, as each position requires distinct anthropometric profiles and body composition, highlighting an interplay between physical attributes and tactical responsibilities (Karkare, 2011).

The positional demands in field hockey further emphasize the significance of anthropometric characteristics. Empirical evidence suggests that stature and body mass significantly impact performance outcomes at the professional level, with particular attributes conferring advantages in specific positions (Reilly & Borrie, 1992). This explanation was further refined through comparative analysis focusing on the physical characteristics of the players, revealing variations in body mass distribution, height, body fat percentage, and body mass index (Cole et al., 2000; Holway & Garavaglia, 2009; Manna et al., 2010).

Therefore, by examining field hockey players' morphological build, our study aims to understand how physical attributes influence performance and contribute to optimizing athletes' training and selection processes. Our study aims to improve the understanding of the relationship between morphological characteristics and performance outcomes in field hockey players, drawing from established theoretical foundations and empirical findings. Specifically, the objective of our study are to:

- Establish comprehensive anthropometric profiles across playing positions
- Analyze the body composition and positional differences among field hockey players

The findings from our study are expected to provide valuable insights that will enhance athlete development, improve competitive strategies, and support the advancement of field hockey training programs.

Materials and Methods

The study was conducted with utmost adherence to the guidelines of the Declaration of Helsinki, with approval granted by the university's ethics committee (reference number DR/IEC/2021/06-16, dated April 1, 2021). Informed consent was obtained from all participants after they were thoroughly informed about the study's purpose and procedure.

The study was conducted in Hisar district of Haryana state, India. The research centered on the Giri Sports complex at CCS Haryana Agricultural University; the sports complex is famous for its "centers of excellence" in athletics, boxing, hockey, and wrestling, mainly.

The study employed a quantitative methodology to evaluate field hockey player's morphological build and body composition. The study was carried out on a sample of 30 female field hockey players. The team practicing under the sports training center (STC), SAI, Giri center, comprises around 40-45 athletes in total, spanning all age groups: sub-junior (under 17), junior (under 20), and senior (20–above). The athletes were studied as a total sample and classified by the player's position: Goalkeeper (n=4), center half (n=12), full back (n=5), and forwards (*n*=9). From an initial pool of 35 athletes who expressed their willingness to participate, a careful selection process based on specific inclusion criteria led to 30 subjects in the study.

Subjects

Thirty female field hockey athletes aged 13-21 years old (16.7±2.17 year) took part in the study. All the participants were state-level players, and some players also performed in the national-level championships. Players were classified into four groups based on their field position. The player's field position was 1:2:4:4; i.e. one goalkeeper, two defenders (full back), four center halfs (midfielders), and four forward players.

Their training program during the three months before the study represented approximately 2.5±0.5 hours daily morning and evening training, including warm-up, training, and warm-down sessions.

Sampling procedure

The participants underwent body composition assessments in the early morning following an overnight fast and at least 12 hours after their last exercise session, with precautions taken to minimize any significant travel the day prior.

Inclusion and exclusion criteria

The primary selection criteria for players were their participation in the game, level of physical fitness, availability, and voluntary consent. The Yo-Yo Intermittent Recovery Level 1 (Yo-Yo IR1) test was selected to evaluate the fitness level of the participants. Only those scoring above 13 on the Yo-Yo IR1 test were selected for the study. Meanwhile, those scoring below 13 were excluded. Further, participant athletic experience was also taken into the consideration during selection process. Only those participants were select for the study who have a minimum of two years of field hockey experience and actively involved in hockey competitions at either the state or national level. Additionally, participants were required to be in good health and injury-free at the time of the study.

Measurements

The methodology for assessing body composition adhered to established protocols, as informed by previous research (Mascherini et al., 2015; Suarez-Arrones et al., 2018). This assessment encompassed the integration of anthropometric measurements, somatotype determination, and bioelectrical impedance analysis (BIA). Prior to the commencement of measurements, all subjects were thoroughly briefed on the measurement procedures.

Anthropometric measurements were performed following the guidelines set forth by the International Society for the Advancement of Kinanthropometry (ISAK). Body Mass Index (BMI) was calculated using Quetelet's Index formula (body mass/height (kg/m2) and categorized based on the World Health Organization's (WHO) established cut-off points (Cole et al., 2000; Nuttall, 2015). Body circumferences were measured using an Anthropometric Tape (CESCORF, Brazil). Skinfold thickness was assessed with a skinfold caliper (Holtain Ltd,). Somatotype was determined according to the Heath-Carter method (Heath & Carter, 1967).

Body density (D) was predicted equation of Durnin & Womersly Equation (1974). And BodyFat% was predited with using Siri Method (Siri 1956).

All the measurements were taken in the morning before breakfast. All the measurements were taken with minimal clothing.

Statistical Analysis

Data were presented according to descriptive statistics (Means ± SD). Shapiro-Wilk test was used to assess the normality of the data, p≤0.05 differences were statistically significant (Toro-Román et al., 2023). Furthermore, the Pearson correlation coefficient was used to find the relationship between anthropometric measurements and body composition parameters (Toro-Román et al., 2023), with the α-value set at 0.05. The correlation value within the range of 0 up to ±0.30 shows negligible, above ±0.30 up to ±0.50 shows low positive (negative) correlation, above ±0.50 up to ±0.70 shows moderate positive (negative) correlation, and above ±0.70 up to ±0.90 shows high positive (negative) correlation (Hinkle et al., 2003; Hu et al., 2015; Kapri et al., 2023).

Results

Anthropometric characteristics of female field hockey players

Anthropometric measurements include body size, depth, circumference and body composition of subjects and wide range of body shapes and compositions were recorded based of subjects' fitness test Yo-Yo IR1. The Table 2 presents a comprehensive overview of various body measurements across four distinct groups of players. Each measurement includes the mean value (Mean±SD), the 5th and 95th percentiles to offer a range (approximately equivalent to the mean±1.65 SD) and a corresponding p-value indicating the statistical significance of differences among the groups.

Table 1. Age and training experience of female field hockey players

Field position	Number	Age (yr)	Training experience (yr)*
Goalkeeper	4	17.5	4.2
Center half	12	16.6	4.5
Full back	5	16	3.2
Forwards	9	16.7	4.1

*All selected participants had more than two years of competitive experience, as detailed in Table 1.

The centre half players were found to be the most experienced in field hockey,

while the representatives of the forward field position were the least experienced

Age distribution among the groups shows a significant difference (p=0.021), with goalkeepers having the highest mean age, whereas mean weight and body mass do not exhibit significant differences (p=0.924 and p=0.445, respectively) across the groups (Table 1) However, variations in body structure become apparent in measurements such as shoulder breadth (p≤0.0001) and knee height (p≤0.0001), where significant differences are observed. Interestingly, side arm reach also shows significant differences (p=0.000), suggesting potential variations in upper body flexibility or arm length.

Moreover, while total arm length and leg length do not show significant differences among groups (p=0.427 and p=0.674, respectively), body breadth and circumference measurements reveal notable distinctions. For instance, biepicondylar humerus breadth demonstrates significant variability (p≤0.0001), indicating differences in upper arm bone structure. Additionally, upper arm and midaxillary circumferences exhibit significant differences (p≤0.0001 and p=0.004, respectively), implying muscle or fat distribution variations.

Skinfold measurements further elucidate differences in subcutaneous fat distribution across groups. Significant variations are observed in biceps, midaxillary, and suprailiac skinfold measurements (p=0.011, p=0.004, and p=0.013, respectively), suggesting divergent patterns of fat accumulation. Similarly, abdominal skinfold measurements reveal significant differences (p=0.035), indicating variations in abdominal fat distribution.

Lastly, while thigh circumference shows significant differences (p=0.032) among groups, calf circumference does not exhibit significant variations (p=0.472). These findings collectively offer insights into the diverse body compositions, proportions, and physical characteristics of the different groups of players occupying different positions in field hockey (Table 2).

Table 2. Anthropometric characteristics of female field hockey players

Variables	Goal keeper (n=4)	Center half (n=12)	Full back (n=5)	Forward (n=9)	Mean ± SD	5th percentile	95th percentile	p-value*
Age (years)	17.5±2.4	16.7±2.1	16.0±1.0	16.8±2..7	16.7±2.2	13.13	20.27	0.021
Body mass (kg)	55.2±3.5	52.2±6.2	52.8±4.8	49.2±3.9	51.8±5.2	43.22	60.41	0.924
Height (cm)	164.5±5.8	162.4±6.1	161.6±0.6	161.1±8.1	162.2±6.1	152.14	172.2	0.445
Body depth (cm)								
Shoulder Breadth	40.5±1.8	44.3±20.5	36.9±5.1	38.6±1.1	40.8±13.2	19.24	62.51	≤0.0001
Side arm Reach	65.2±9.9	62.9±7.9	62.0±7.5	64.1±6.2	63.5±07.3	51.45	75.44	0
Total arm length	55.1±4.1	53.4±2.4	53.1±2.2	52.3±3.3	53.2±2.9	48.54	57.93	0.427
Knee height	51.6±2.1	49.1±3.6	44.6±9.2	48.5±3.5	48.5±4.9	40.33	56.58	≤0.0001
Total Leg length	95.8±3.3	92.9±3.8	92.3±1.2	92.5±6.2	93.1±4.3	85.95	100.15	0.674
Breadth (cm)								
Biepicondylar Femur	7.5±1.4	7.7±0.8	6.9±0.7	7.5±0.9	07.5±0.9	5.97	8.99	0.087
Biepicondylar Humerus	6.3±1.3	5.3±0.4	5.6±0.30	5.2±0.4	5.5±0.7	4.4	6.53	≤0.0001
Circumference (cm)								
Upper arm	34.1±21.3	25.3±7.9	31.8±17.6	22.8±1.1	26.8±11.5	7.98	45.67	≤0.0001
Thigh	45.9±2.1	45.8±3.8	46.7±2.2	45.6±2.7	45.9±2.9	41.02	50.77	0.032
Calf	31.1±2.5	31.1±2.7	31.4±2.2	29.7±2.8	30.7±2.6	26.45	34.94	0.472
Skin fold (mm)								
Biceps	14.1±3.6	12.8±3.5	12.9±4.2	13.9±3.5	13.3±3.5	7.55	19.07	0.011
Triceps	18.2±4.5	16.4±4.3	15.7±1.8	14.6±3.6	15.9±3.8	9.72	22.23	0.672
Subscapular	12.5±2.9	12.1±2.7	14.88±1.19	13.7±2.4	13.1±2.6	8.87	17.34	0.801
Chest	13.2±2.9	13.0±3.6	13.3±2.2	13.9±5.1	13.4±3.7	7.26	19.48	0.056
Midaxillary	13.3±1.3	14.7±4.9	14.1±2.2	13.1±4.1	13.9±3.9	7.45	20.37	0.004
Suprailiac	12.1±2.3	13.8±4.7	13.5±2.1	13.5±2.9	13.4±3.5	7.63	19.17	0.013
Abdominal	18.2±5.2	19.0±6.7	16.6±2.9	17.1±3.4	17.9±5.1	9.68	26.16	0.035
Thigh	17.6±4.2	16.9±6.2	17.6±3.4	17.1±3.7	17.2±4.7	9.51	24.82	0.497
Calf	14.4±6.9	14.3±3.3	11.9±1.9	13.6±3.8	13.7±3.8	7.47	19.97	0.215

* p≤0.05

Physical profile of female field hockey players

Data in Table 3 shows the physical profile of the subjects on the basis of the anthropometric data. At the 5th percentile, subjects' BMI fell under the underweight category (16.90kg/m²), at the 50th (19.70±1.70kg/m²), and at the 95th percentile (22.50kg/m²), it was under the normal category. Regarding the average fat percentage was reported as 19.24±3.00, which showed the normal distribution (Table 3).

For the 5th percentile subjects' fat percent was reported as 14.31% and for 95th percentile fat percentage it was 24.18%. Good fat percent for female ranges between 16-23% but for the female field hockey players 12-18% fat percentage was reported by Halson et al. (2004). Fat weight was 9.97±1.90 kg, similarly 5th and 95th percentile of subjects' fat weight was calculated as 6.84 kg and 13.10 kg, respectively. Mean lean body mass was 41.85±4.45 kg, whereas for 5th percentile it was 34.53 kg and for 95th percentile it was 49.16 kg. Body density for 50th percentile was 2.40±0.42 g/cm3, for 5th percentile was 1.71 g/cm3 and for 95th percentile was 3.10 g/cm3.

Table 3 further provides a detailed comparison of the physical profiles of subjects divided into four distinct categories: goalkeepers, central defenders, fullbacks, and forwards by evaluating different body composition parameters

Table 3. Physical Characteristics of female Field Hockey players

Parameters	Goal keeper	Center half	Full back	Forward	Mean±SD	5th percentile	95th percentile	p-value*
4 Skinfold (mm)	64.3±19.2	60.4±17.3	58.1±11.4	59.2±14.7	55.8±13.4	33.77	77.79	0.068
6 Skinfold (mm)	92.9±25.9	92.5±27.9	90.2±13.3	89.6±19.8	91.3±23.3	52.88	129.68	0.015
BMI (kg/m²)	20.5±1.8	19.7±1.9	20.2±1.9	18.9±1.2	19.7±1.7	16.9	22.5	0.354
Fat%	21.3±4.5	21.3±3.6	19.7±1.4	19.3±3.3	20.3±3.3	14.8	25.79	0.463
Fat weight (kg)	10.8±2.7	10.3±2.0	10.3±1.8	9.0±1.2	9.9±1.9	6.84	13.1	0.363
Fat Mass Index	4.1±1.1	3.9±0.8	3.9±0.7	3.5±0.6	3.8±0.8	2.54	5.07	0.027
Lean body mass (kg) [1]	44.4±1.5	41.9±5.1	42.5±4.2	40.2±4.5	41.8±04.4	34.53	49.16	0.409
Body Density (g/cm3)	2.39±0.5	2.35±0.4	2.35±0.4	2.51±0.5	2.40±0.4	1.71	3.1	0.006

*p≤0.05

The analysis of skinfold thickness at 4 mm and 6 mm sites across these groups reveals a notable variance in subcutaneous fat distribution, with the goalkeepers displaying significantly higher average skinfold measurements (64.3±19.2 mm and 92.9±25.9 mm, respectively) in comparison to their counterparts. Although the body mass index (BMI) showcases minimal disparities among the groups, ranging from 18.9±1.2 kg/m² in forwards to 20.5±1.8 kg/m² in goalkeepers, the percentile ranges indicate considerable within-group variation.

Fat weight and Fat Mass Index (FMI) were very similar in all groups, albeit with goalkeepers exhibiting a marginally higher fat weight (10.8±2.8 kg) than central defenders (10.3±2.0 kg) and fullbacks (10.3±1.8 kg). The analysis of lean body mass and lean body weight underscores disparities in muscle and non-fat tissue distribution, with goalkeepers showing a higher lean body mass (44.4±1.8 kg) in contrast to forwards (40.2±4.5 kg).

Table 4. Somatotype characteristics of female field hockey players

Somatotype	**Goalkeeper**	**Center half**	**Full back**	**Forward**	**Mean±SD**	**p-value***
Component						
Endomorphy	4.4±0.6	4.5±0.8	4.7±0.4	4.4±0.5	4.5±0.6	0.679
Mesomorphy	3.80±3.59	1.71±1.99	2.82±3.15	0.96±0.71	01.95±02.30	≤0.0001
Ectomorphy	3.06±1.25	3.30±1.10	3.00±0.95	3.61±1.08	03.31±01.06	0.127
Classification	Mesomorphic endomorph	Ectomorphic endomorph	Balanced endo morph	Ectomorphic endomorph	Ectomorphic endomorph	-

* p≤0.05

Table 4 summarizes the somatotype characteristics of female field hockey players, which are valuable in sports where body shape can impact athlete performance. The mean endomorph component was recorded as 4.5±0.6, mesomorphic components as 1.9±2.3, and ectomorphic component as 3.3±1.1. The table also indicates that the overall somatotype of the subjects fell predominantly into the Ectomorphic endomorph category. This suggests that female field hockey players exhibited characteristics of both ectomorphs and endomorphs, with potentially less emphasis on mesomorphic traits.

Figure 1 exhibits the dispersion of somatotype indices by box plot. The significant difference among the somatotype indices is explained by quartile range. The box consists of the lower/first quartile (Q1), median (solid line), and upper/third quartile (Q3); the square inside the box represents the mean. The whiskers represent the range of values, minimum and maximum range of the data.

Endomorphic data of female field hockey players ranged between 3.3-5.6 (minimum and maximum) with an outlier (6.1). Interquartile range box showed first quartile (Q1) at 4.0 and third quartile (Q3) at 4.8. Median of the distribution was 4.4. Mean and median overlapped, which shows the symmetric distribution.

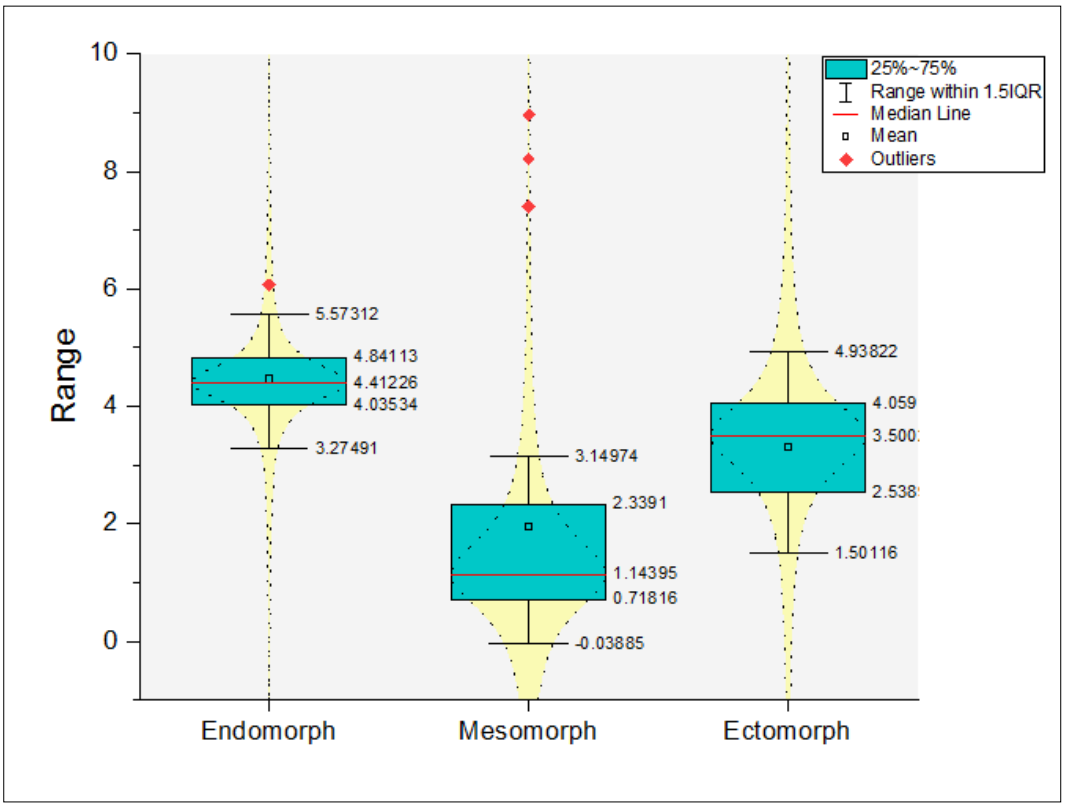

Figure 1. Somatotype categorization

The minimum and maximum range of the mesomorphic indices was 0-3.1 and three outliers were reported at 7.4, 8.2 and 8.9. First quartile (Q1) and third quartile (Q3) value was 0.7 and 2.3 respectively and median within interquartile range was 1.1.

For ectomorph indices, minimum and maximum ranges varied from 1.5 to 4.9. The interquartile box range showed the first quartile Q1=2.5, median Q2=3.5 and third quartile Q3=4.1.

Figure further illustrated that ectomorphic data exhibited the greatest dispersion, followed by mesomorphic and endomorphic data. The endomorphic data showed normal skewness, whereas mesomophic data is positively skewed and ectomorphic data is negatively skewed.

Division of the subjects' somatotypes into sub-categories

Distribution of Players according to Somatotype categories were shown in Figure 2. In the present analysis, out of the thirteen somatotype categories six categories were reported namely Mesomorphic-Endomorph (03.33%), Endomorphic-Mesomorph (10.00%), Balanced Endomorph (10.00%), Endomorphic-Ectomorph (13.33%), Endomorph-Ectomorph (30.00%), and Ectomorphic- Endomorph (33.33%).

Correlation among the physical parameters of female field hockey players

Table 5 shows the correlation among the physical variables and its measures such as age, height, weight, BMI, BMR, fat percentage, fat weight, lean body mass, body density, and somatotype characters. Subject's age showed negligible to low correlation with almost all variables, whereas the weight of the subjects showed a significantly high correlation with LBM ($r=0.935$, $p\leq0.05$) and BMI ($r=0.705$, $p\leq0.05$).

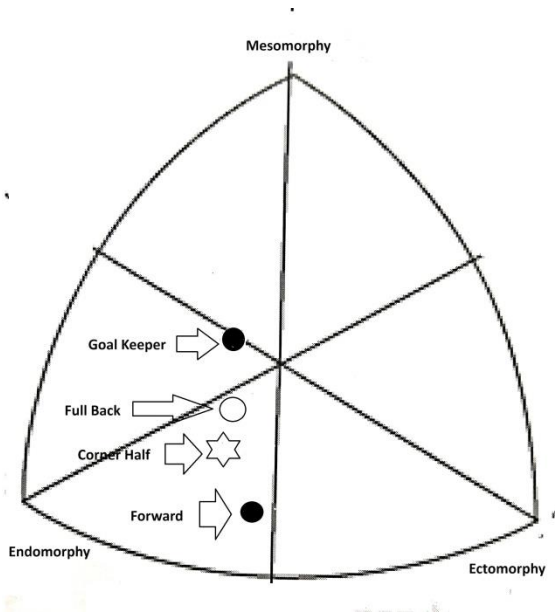

Figure 2. Distribution of players in Somatochart

As the weight of the subjects directly related to the availability of fat in the subjects' bodies, fat percentage showed a negligible (r=0.007, p≥0.05) relation with body weight, whereas fat weight was moderately (r=0.561, p≤0.05) correlated with body weight. Same as body fat percent, somatotype characteristics of the subject's body (endomorphic, mesomorphic, and ectomorphic) exhibit negligible (r= 0.221, 0.242, p≥0.05) to low (negative r=-0.386, p≤0.05) correlation with subjects body weight. The height of the subjects showed a significantly positive relationship with LBM (r=0.639, p≤0.05) and ectomorphic somatotype (r=0.550, p≤0.05). However, height showed low (negative) relationship with fat percentage (r=-0.335, p≥0.05) and endomorphic somatotype (r=-0.451, p≤0.05).

Table 5. Correlation among the physical parameters of female field hockey players

Variables	Age	Wt.	Ht.	BMI	BMR	Fat %	Fat wt	Lean B.wt	B. Density	Endo	Meso	Ecto	x coordinate	y coordinate
Age	1	-0.10	0.23	-0.33	-0.22	-0.22	-0.22	-0.03	0.22	-0.40	-0.01	0.37	0.41	-0.04
Wt.		1	0.56*	0.71**	0.98**	0.01	0.56*	0.94**	0.02	0.22	0.24	-0.39	-0.35	0.29
Ht.			1	-0.20	0.63*	-0.34	0.03	0.64*	0.28	-0.45	-0.10	0.55*	0.55	-0.16
BMI				1	0.63*	0.29	0.63*	0.56*	-0.22	0.64*	0.37	-0.93**	-0.88**	0.48
BMR					1	-0.02	0.55*	0.93**	0.03	0.17	0.19	-0.29	-0.27	0.23
Fat %						1	0.83**	-0.35	-0.99**	0.41	0.33	-0.37	-0.42	0.35
Fat wt.							1	0.23	-0.81**	0.43	0.42	-0.52	-0.52	0.46
Lean B.wt.								1	0.37	0.08	0.11	-0.23	-0.19	0.15
B. Density									1	-0.34	-0.28	0.29	0.33	-0.29
Endo										1	0.38	-0.72	-0.88**	0.40
Meso											1	-0.36	-0.40	0.99**
Ecto												1	0.96**	-0.47

Wt.=Weight, Ht.= Height, BMI=Body mass index, BMR=Basal metabolic rate, B.= Body, Endo= Endomorphic, Meso=Mesomorphic, Ecto=Ectomorphic; $p \leq 0.05$

BMI is the combination of subjects' body weight and height, but in the correlation analysis, it showed a significantly positive relationship with body weight (r=0.705, p≤0.05) and a negligible relationship with height (r=-0.195, p≥0.05) of the subjects. BMI further showed a significantly positive relation (p≤0.05) with fat weight (r=0.631) and LBM (r=0.559), whereas it showed almost negligible association (p≥0.05) with fat percentage (r=0.290) and body density (r=-0.217). Regarding somatotype characteristics, BMI showed a significantly positive relationship with endomorph (r=0.637, p≤0.05) and a highly negative relationship with ectomorph (r=-0.925, p≤0.05). Fat percentage significantly correlates with fat weight (r=0.827, p≤0.05). Fat percentage and fat weight both were negatively correlated with body density (r=-0.985 and -0.808, p≤0.05) and both have low correlation with endomorph (r=0.414, 0.432, p≤0.05) and mesomorph (r=0.331, p≥0.05; 0.415, p≤0.05) somatotype characteristic. LBM and body density have an almost negligible relationship with somatotype characteristics (ranged from r=-0.337 to 0.286, p≥0.05). Endomorphic characteristics have weak relation (r=-0.359, p≥0.05) with mesomorph, whereas ectomorphic somatotype characteristic showed highly negative relationship with endomorph (r=-0.721, p≥0.05) and low negative relation with mesomorph.

Discussion

This study aimed to evaluate female field hockey players' anthropometric characteristics, body composition, and somatotype, providing essential insights for optimizing player performance and tailoring training programs. Our findings indicate significant variations in physical attributes across different playing positions, which are crucial for understanding the specific demands and enhancing the performance of field hockey players.

In field hockey, teams typically comprise ten players and one goalkeeper, as outlined in the Rules of Hockey. In the present study, a cohort of thirty physically fit athletes participated, with players assuming various field positions. The age range of the subjects spanned from 12 to 21 years, with a majority of participants possessing 5 to 9 years of experience in the sport.

The participants' mean age, weight, and height were determined to be 16.70±2.17 years, 51.82±5.23 kg, and 162.17±6.10 cm, respectively. Significantly, the calculated body mass index (BMI) of 21.22 kg/m² fell within the normal range for both the 50th and 95th percentiles of the subjects. Comparable findings were reported by Ucan (2015) in an investigation involving national-level field hockey players (mean age: 19.6±0.8 years; weight: 56±6.1 kg; height: 162.1±4.8 cm). Body height, weight, and BMI parameters exhibited normal distribution and displayed varying degrees of correlation. Notably, there is a significant positive correlation of weight and height with Lean Body Mass (LBM), suggesting that increased weight is closely linked to greater lean mass. Taller players tend to have greater lean body mass, which implies that height contributes to muscle development (Hume, 1966; Puri & Blake, 2022) in female field hockey players. However, height has a negligible correlation with BMI, indicating that weight is a more critical factor for BMI (Summer et al., 2024) within this sample. Furthermore, fat percentage exhibits a strong positive correlation with fat weight, indicating that higher fat weight is associated with a greater percentage of body fat (Fedotova, 2001). Both fat measures are negatively correlated with body density, demonstrating that an increase in fat percentage and fat weight corresponds to a decrease in body density (Summer et al., 2024).

The anthropometric data further revealed significant positional differences in several key measurements. Goalkeepers exhibited the highest mean values in shoulder breadth (40.51±1.81 cm) and knee height (51.56±2.10 cm), which are significantly broader and higher than those of other players. These attributes likely contribute to better defensive capabilities, allowing goalkeepers to cover more area and block shots more effectively. Similar findings have been reported by Reilly & Borrie (1992) who emphasized the importance of such physical attributes for goalkeepers. Height and weight showed less variation across positions, with mean values of 162.17±6.10 cm and 51.82±5.23 kg, respectively. However, the significant differences in shoulder breadth and knee height underscore the necessity for position-specific physical training and development.

Skinfolds and body density have been widely utilized to estimate body composition in athletes and other populations. However, both methods have limitations related to the constants used in equations to convert their values into percentage fat. Skinfold measurements provide valid assessments of skin and subcutaneous tissues at specific sites on the body. However, it is essential to note that skinfold measurements can only approximate overall body fatness. In this study, skinfolds and body density use highlighted the significant variability in body composition among players in different positions.

The present study evaluated % body fat (%BF) via skinfold equations (Bacchi et al., 2017). Age, gender, and obesity play significant roles in skinfold measurements and body density assessments, as a consistent skinfold level can correspond to varying fat distribution patterns across different age groups (Silveira et al., 2020). The

reported mean fat percentage was 19.24±3.00%, ranging from 14.31% to 24.18%. These results are slightly higher than those typically reported for male players but are consistent with previous studies by Wassmer & Mookerjee (2002), Astorino et al. (2004), Ucan (2015), Hirani & Mindell (2008), Machado et al. (2010), and Silveira et al. (2020). Some studies on body composition measurement also discussed that while skinfolds are valid measures of the skin and subcutaneous tissues at each site, they can only approximate the fatness of the body (Heath & Carter, 1967).

It was reported that goalkeepers had the highest skinfold measurements (64.28±19.17 mm for four skinfolds and 92.90±25.93 mm for 6 skinfolds), indicating higher subcutaneous fat levels. These findings align with previous research by Bacchi et al. (2017), which noted that goalkeepers, due to their less intense aerobic demands, tend to have higher body fat percentages than field players. Conversely, forwards exhibited lower body fat percentages (mean %BF of 18.48±3.23% by the Durnin and Womersley method), reflecting their need for agility and speed. These values are consistent with the typical body composition of female athletes, as outlined by Gleeson et al. (2004), who reported optimal body fat percentages for female field hockey players to range between 12-18%.

Furthermore, Using the Heath-Carter method for somatotype analysis, the results indicated that most players fell into the ectomorphic-endomorph category, with mean somatotype indices of 4.47-1.95-3.31. This classification indicates a balance of lean and endomorphic characteristics, which can be advantageous for maintaining agility while ensuring sufficient body mass for physical confrontations. Heath & Carter (1967) also observed similar trends in somatotype characteristics among male and female hockey players.

Recognizing that defenders, midfielders, forwards, and goalkeepers have distinct physical requirements and responsibilities, there are better approaches to training and nutrition than a one-size-fits-all approach to training and nutrition. By integrating position-specific strategies, individual player performance can be improved, and the team's overall effectiveness and success can also be significantly enhanced. This research provides practical insight for coaches on creating training and dietary plans tailored to each player's position. It further helps to improve performance and lower the chance of injury. The findings could also help improve training methods in different team sports, aiming to keep athletes healthy and successful. Future research should concentrate on longitudinal studies to evaluate the impact of customized training programs, particularly focusing on the relationship between morphological attributes and performance metrics across different competitive levels.

Conclusion

The present study on female field hockey players exhibited significant position-specific variations in physical characteristics and body composition parameters such as shoulder breadth and knee height. Body composition analysis revealed distinct patterns, where goalkeepers showed higher values in fat percentage and lean body mass compared to other field players. The predominant ectomorphic-endomorph somatotype classification was observed across positions, providing comprehensive insights into the player's morphological characteristics. Strong correlations between anthropometric measurements and body composition characters suggest position specific training to optimize individual performance.

References

Astorino, T.A., Tam, P.A., Rietschel, J.C., Johnson, S.M., Freedman, T.P. (2004). Changes in physical fitness parameters during a competitive field hockey season. The Journal of Strength & Conditioning Research, 18(4): 850–854. https://doi.org/10.1519/00124278-200411000-00029

Bacchi, E., Cavedon, V., Zancanaro, C., Moghetti, P., Milanese, C. (2017). Comparison between dual-energy X-ray absorptiometry and skinfold thickness in assessing body fat in overweigh/obese adult patients with type-2 diabetes. Scientific Reports, 7(1): 17424. https://doi.org/10.1038/s41598-017-17788-y

Carter, J.E.L. (2002). Part 1: The Heath-Carter anthropometric somatotype-instruction manual. Department of Exercise and Nutritional Sciences San Diego State University.1-26

Cole, T.J., Bellizzi, M.C., Flegal, K.M., Dietz, W.H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj, 320: 1240. https://doi.org/10.1136/bmj.320.7244.1240

Durnin, J.V, Womersley, J.V.G.A (1974a). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. British Journal of Nutrition, 32(1): 77–97.

Durnin, J.V.G.A., Rahaman, M.M. (1967). The assessment of the amount of fat in the human body from measurements of skinfold thickness. British Journal of Nutrition, 21(3): 681–689. https://doi.org/10.1079/BJN19670070

Durnin, J.V.G.A., Womersley, J. (1974b). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. British Journal of Nutrition, 32(1): 77–97.

Fedotova, E. (2001). Morphological, Functional, and Fitness-Related Characteristics of Young Female Field Hockey Players. Women in Sport and Physical Activity Journal, 10(2): 145–168. https://doi.org/10.1123/wspaj.10.2.145

Gleeson, M., Nieman, D.C., Pedersen, B.K. (2004). Exercise, nutrition and immune function. Food, Nutrition and Sports Performance, Journal of sports sciences, 22(1), 115-125.

Halson, S.L., Lancaster, G.I., Achten, J., Gleeson, M., Jeukendrup, A.E. (2004). Effects of carbohydrate supplementation on performance and carbohydrate oxidation after intensified cycling training. Journal of Applied Physiology, 97(4): 1245–1253. https://doi.org/10.1152/japplphysiol.01368.2003

Heath, B.H., Carter, J.E.L. (1967). A modified somatotype method. American Journal of Physical Anthropology, 27(1): 57–74. https://doi.org/10.1002/ajpa.1330270108

Hinkle, D.E., Wiersma, W., Jurs, S.G. (2003). Applied statistics for the behavioral sciences (Vol. 663). Houghton Mifflin Boston.

Hirani, V., Mindell, J. (2008). A comparison of measured height and demi-span equivalent height in the assessment of body mass index among people aged 65 years and over in England. Age and Ageing, 37(3): 311–317. https://doi.org/10.1093/ageing/afm197

Holway, F.E., Garavaglia, R. (2009). Kinanthropometry of group I rugby players in Buenos Aires, Argentina. Journal of Sports Sciences, 27(11): 1211–1220. https://doi.org/10.1080/02640410903207408

Hu, H.M., Zhao, C.Y., Zhang, X., Ran, L.H., Liu, T.J. (2015). Correlation analysis on the main and basic body dimension for Chinese adults. Digital Human Modeling. Applications in Health, Safety, Ergonomics and Risk Management: Ergonomics and Health: 6th International Conference, DHM 2015, Held as Part of HCI International 2015, Los Angeles, CA, USA, August 2-7, 2015, Proceedings, Part II 6, Springer International Publishing,37–43.

Hume, R. (1966). Prediction of lean body mass from height and weight. Journal of Clinical Pathology, 19(4): 389–391. https://doi.org/10.1136/jcp.19.4.389

Kapri, E., Dey, S., Mehta, M., Deshpande, N., Zemková, E. (2023). Analysis of Daily Activity Pattern to Estimate the Physical Activity Level and Energy Expenditure of Elite and Non-Elite Athletes. Applied Sciences, 13(5): 2763. https://doi.org/10.3390/app13052763

Karkare, A. (2011). Anthropometric measurements and body composition of hockey players with respect to their playing positions. Indian Streams Research Journal, 1: 5–8.

López-Fernández, J., García-Unanue, J., Sánchez-Sánchez, J., Colino, E., Hernando, E., Gallardo, L. (2020). Bilateral asymmetries assessment in elite and sub-elite male futsal players. International Journal of Environmental Research and Public Health, 17(9): 3169. https://doi.org/10.3390/ijerph17093169

Machado, R.S.P., Coelho, M.A.S.C., Coelho, K.S.C. (2010). Percentual de gordura corporal em idosos: comparação entre os métodos de estimativa pela área adiposa do braço, pela dobra cutânea tricipital e por bioimpedância tetrapolar. Revista Brasileira de Geriatria e Gerontologia, 13(1): 17–27. https://doi.org/10.1590/S1809-98232010000100003

Manna, I., Khanna, G.L., Dhara, P.C. (2010). Effect of training on anthropometric, physiological and biochemical variables of elite field hockey players. International Journal of Sports Science and Engineering, 4(4): 229–238.

Mascherini, G., Petri, C., Galanti, G. (2015). Integrated total body composition and localized fat-free mass assessment. Sport Sciences for Health, 11: 217–225. https://doi.org/10.1007/s11332-015-0228-y

McGuigan, M.R., Cormack, S.J., Gill, N.D. (2013). Strength and Power Profiling of Athletes. Strength & Conditioning Journal, 35(6): 7–14. https://doi.org/10.1519/SSC.0000000000000011

Nuttall, F.Q. (2015). Body mass index: obesity, BMI, and health: a critical review. Nutrition Today, 50(3): 117–128. https://doi.org/10.1097/NT.0000000000000092

Petri, C., Campa, F., Hugo Teixeira, V., Izzicupo, P., Galanti, G., Pizzi, A., Badicu, G., Mascherini, G. (2020). Body fat assessment in international elite soccer referees. Journal of Functional Morphology and Kinesiology, 5(2): 38. https://doi.org/10.3390/jfmk5020038

Puri, T., Blake, G.M. (2022). Comparison of ten predictive equations for estimating lean body mass with dual-energy X-ray absorptiometry in older patients. The British Journal of Radiology, 95(1133): 20210378. https://doi.org/10.1259/bjr.20210378

Reilly, T., Borrie, A. (1992). Physiology applied to field hockey. Sports Medicine, 14: 10–26. https://doi.org/10.2165/00007256-199214010-00002

Silveira, E.A., Barbosa, L.S., Rodrigues, A.P.S., Noll, M., De Oliveira, C. (2020). Body fat percentage assessment by skinfold equation, bioimpedance and densitometry in older adults. Archives of Public Health, 78: 1–9. https://doi.org/10.1186/s13690-020-00449-4

Singh, S., Singh, K., Singh, M. (2010). Anthropometric measurements, body composition and somatotyping of high jumpers. Brazilian Journal of Biomotricity, 4(4): 266–271.

Suarez-Arrones, L., Petri, C., Maldonado, R.A., Torreno, N., Munguía-Izquierdo, D., Di Salvo, V., Méndez-Villanueva, A. (2018). Body fat assessment in elite soccer players: cross-validation of different field methods. Science and Medicine in Football, 2(3): 203–208. https://doi.org/10.1080/24733938.2018.1445871

Summer, L.C., Cheng, R., Moran, J.T., Lee, M., Belanger, A.J., Taylor IV, W.L., Gardner, E.C. (2024). Changes in Body Composition and Athletic Performance in National Collegiate Athletic Association Division I Female Field Hockey Athletes Throughout a Competitive Season. The Journal of Strength & Conditioning Research, 38(1): 146–152. https://doi.org/10.1519/JSC.0000000000004591

Toro-Román, V., Robles-Gil, M.C., Muñoz, D., Bartolomé, I., Grijota, F.J., Maynar-Mariño, M. (2023). Sex differences in cadmium and lead concentrations in different biological matrices in athletes. Relationship with iron status. Environmental Toxicology and Pharmacology, 99: 104107. https://doi.org/10.1016/j.etap.2023.104107

Ucan, Y. (2015). Effect of National-Level Field Hockey on Physical Fitness and Body Composition Parameters In Turkish Females. The Sport Journal, 1–9. https://doi.org/10.17682/sportjournal/2015.014

Wassmer, D.J., Mookerjee, S. (2002). A descriptive profile of elite US women's collegiate field hockey players. Journal of Sports Medicine and Physical Fitness, 42(2): 165.

Acknowledgment

The authors acknowledge the support and contribution of the coaches and the athletes of the sports training center.

Data availability

Full access to data on request.

Funding

There is no external funding to declare.

Conflicts of Interest

The authors declare that he has no competing interests.

Informed Consent

Statement all the athletes and their parents included in the study provided written informed consent.

About the License