Somatotype Characteristics of Elite Male and Female Kho-Kho Players: A Comparative Study

Uppuluri Lakshmi Mallikarjuna Vivek [1, *], Gopi Kabber Sunil Kumar [1],

Shwetha Rai Balakrishna [1], Vijaya Vageesh Yogeshwaran [1], Rajeshwari Lokeshwaraiah [1],

Rajalakshmi Ramashetty [1]

[1] Department of Physiology, JSS Medical College, Mysuru, India
* Corresponding Author Email: ulmvivek09@gmail.com

Abstract

Introduction: Kinanthropometry provides an evidence-based approach to quantify physique, body composition, and performance-related traits in athletes. Kho-Kho, a traditional Indian team sport, demands agility, speed, and endurance. Evaluating gender-specific somatotype characteristics through comprehensive anthropometric assessment can enhance athlete profiling and training design. **Methods:** Fifty national-level elite Kho-Kho players (25 males, 25 females) from Karnataka were assessed using standardized Kinanthropometric protocols. Measurements included body mass, height, sitting height, and arm span. Skinfold thickness at eight sites (triceps, subscapular, biceps, iliac crest, supra-spinal, abdominal, thigh, calf) was obtained using skin fold caliper; girths (arm relaxed, arm flexed, waist, hip, thigh, calf) with an anthropometric tape; and bone breadths (humerus, bistyloid, femur) with a sliding bone caliper. Derived indices included Body Mass Index (BMI) and somatotype components (endomorphy, mesomorphy, ectomorphy) calculated via the Heath–Carter method. Gender comparisons were made using independent t-tests or Mann–Whitney U tests, with Holm–Bonferroni correction applied for multiple comparisons. **Results:** Males displayed significantly higher height, weight, mesomorphy, and musculoskeletal dimensions (bone breadths and muscle girths), while females exhibited greater endomorphy and higher skinfold thickness. Differences in ectomorphy were not statistically significant. After Holm–Bonferroni adjustment, mesomorphy remained higher in males ($p < 0.05$), and endomorphy remained higher in females ($p < 0.05$). **Conclusion:** Elite male Kho-Kho players are predominantly mesomorphic with enhanced muscularity and skeletal robustness, whereas females demonstrate greater endomorphy reflecting higher fat-related body composition. These gender-specific somatotype profiles underscore the physiological demands of Kho-Kho and provide a scientific basis for athlete monitoring, training, and talent development.

Keywords: Kho Kho, Kinanthropometry, Somatotype, BMI, Gender.

Características somatotípicas de jugadores de élite masculinos y femeninos de Kho-Kho: Un Estudio Comparativo

Resumen

Introducción: La cineantropometría proporciona un enfoque basado en la evidencia para cuantificar el físico, la composición corporal y los rasgos relacionados con el rendimiento en los atletas. El Kho-Kho, un deporte de equipo tradicional indio, exige agilidad, velocidad y resistencia. La evaluación de las características somatotípicas específicas de género a través de una evaluación antropométrica integral puede mejorar el perfil del atleta y el diseño del entrenamiento. **Métodos:** Se evaluó a cincuenta jugadores de Kho-Kho de élite a nivel nacional (25 hombres, 25 mujeres) de Karnataka utilizando protocolos cineantropométricos estandarizados. Las mediciones incluyeron masa corporal, altura, altura sentada y envergadura de brazos. El grosor del pliegue cutáneo en ocho sitios (tríceps, subscapular, bíceps, cresta ilíaca, supraespinal, abdominal, muslo, pantorrilla) se obtuvo utilizando un calibrador de pliegues cutáneos; las circunferencias (brazo relajado, brazo flexionado, cintura, cadera, muslo, pantorrilla) con una cinta antropométrica; y las anchuras óseas (húmero, biestiloides, fémur) con un calibrador

óseo deslizante. Los índices derivados incluyeron el Índice de Masa Corporal (IMC) y los componentes del somatotipo (endomorfia, mesomorfia, ectomorfia), calculados mediante el método de Heath-Carter. Las comparaciones de género se realizaron mediante pruebas t independientes o pruebas U de Mann-Whitney, con corrección de Holm-Bonferroni aplicada para comparaciones múltiples. **Resultados:** Los hombres mostraron una estatura, un peso, una mesomorfia y dimensionesmusculoesqueléticas (anchura ósea y perímetro muscular) significativamente mayores, mientras que las mujeres mostraron mayor endomorfia y mayor grosor del pliegue cutáneo. Las diferencias en ectomorfia no fueron estadísticamente significativas. Tras el ajuste de Holm-Bonferroni, la mesomorfia se mantuvo más alta en los hombres (p < 0,05) y la endomorfia se mantuvo más alta en las mujeres (p < 0,05). **Conclusión:** Los jugadores de élite de Kho-Kho son predominantemente mesomórficos, con mayor musculatura y robustez esquelética, mientras que las mujeres muestran una mayor endomorfia, lo que refleja una mayor composición corporal relacionada con la grasa. Estos perfiles de somatotipo específicos de género subrayan las exigencias fisiológicas del Kho-Kho y proporcionan una base científica para el seguimiento, el entrenamiento y el desarrollo del talento de los atletas.

Introduction

Kinanthropometry is widely recognized as a scientific discipline that quantifies human physique, body composition, and performance-related traits, thereby enabling evidence-based profiling of athletes (Carter & Heath, 1990; Duquet & Carter, 2001). The somatotype method, particularly the Heath–Carter approach, has been extensively applied across sports to determine optimal morphological characteristics for specific performance demands (Tóth et al., 2014). Somatotyping divides human physique into three components—endomorphy (relative fatness), mesomorphy (musculoskeletal robustness), and ectomorphy (linearity)—which collectively reflect an athlete's morphological status (Carter, 1996; Ross et al., 1982).

Kho-Kho, a traditional Indian tag sport, is one of the most physically demanding indigenous games, requiring a blend of agility, speed, flexibility, endurance, and tactical awareness (Manohar, 2015). As a high-intensity pursuit-and-evade game, performance in Kho-Kho is influenced not only by technical and tactical proficiency but also by anthropometric and somatotype characteristics (Ravinder & Kumar, 2024). Previous studies on indigenous sports have consistently shown that physique and somatotype are sport-specific determinants of performance. For instance, medalist Kho-Kho players were reported to exhibit greater mesomorphy and muscular development compared to non-medalists, who tended to be more endomorphic or ectomorphic (Manohar, 2015). Similarly, correlations between anthropometric traits such as height, leg length, and girth dimensions with speed and endurance have been established among elite Kho-Kho players, reinforcing the predictive value of somatotyping in performance outcomes (Ravinder & Kumar, 2024).

Comparative evidence from other sports also supports the importance of somatotype profiling. In Kabaddi, positional differences were marked, with raiders demonstrating taller stature, longer arm span, and lower fat mass compared to defenders, highlighting the role of somatotype in role specialization (Dhanjal, 2024). In aquatic sports, Indian female rowers exhibited a mesomorphic-endomorphic profile with relatively low muscularity, which was associated with limited success at the international level (Adhikari & Chakrabarti, 2022). Similarly, canoeists and kayakers demonstrated sex-based somatotype differences, with males showing balanced mesomorphy and females tending toward mesomorphic endomorphy, suggesting that inadequate muscularity may hinder international competitiveness (Chakrabarti & Adhikari, 2023). These findings indicate that gender-specific variations in somatotype not only exist across sports but also strongly influence performance potential.

Despite this evidence, literature specifically addressing gender-based somatotype profiles in Kho-Kho remains scarce, even though the sport demands a unique blend of anthropometric and morphological attributes. Studies on Bangladeshi female Kho-Kho and football players found Kho-Kho athletes to possess longer legs and better physique indices, yet comparable fat percentages, suggesting distinct physical advantages linked to Kho-Kho (Rickta et al., 2024). However, comprehensive comparative analyses of male and female elite Kho-Kho players at the national level are lacking.

Given this gap, the present study sought to examine the somatotype characteristics of elite male and female Kho-Kho players using standardized kinanthropometric protocols. By analyzing gender-specific variations in anthropometric traits and somatotype components, this study aims to contribute evidence for athlete monitoring, performance optimization, and sport-specific training design in Kho-Kho.

Materials and Methods

Participants

The study included 50 national-level elite Kho-Kho players (25 males and 25 females) representing Karnataka, India. All participants were between the ages of 18 and 26 years and were actively competing at the national level. Inclusion criteria required athletes to be free from injury at the time of testing and to have at least three years of competitive experience. Written informed consent was obtained from all participants prior to data collection. Ethical clearance was granted in accordance with institutional research guidelines. (JSSMC/IEC/972025/78 NCT/2025-26) and the Declaration of Helsinki (World Medical Association, 2013).

Measurements

Anthropometric measurements were performed according to the International Society for the Advancement of Kinanthropometry (ISAK) standards (ISAK, 2019. 2023). All assessments were carried out under standardized conditions, with participants barefoot and in light athletic clothing.

1. **Basic measurements**:

   o Body mass (kg) was measured using a weighing scale (to the nearest 0.1 kg).

   o Height (cm) was measured using a stadiometer.

   o Sitting height and arm span were measured using a stadiometer and anthropometric tape, respectively.

2. **Skinfold thickness** (mm): Eight sites were measured using a calibrated skinfold caliper: triceps, subscapular, biceps, iliac crest, supra-spinal, abdominal, thigh, and calf. Each site was measured twice, with a third trial if readings differed by more than 0.5 mm, and the mean was used for analysis.

3. **Girths** (cm): Arm relaxed, arm flexed, waist, hips, thigh (midpoint), and calf girths were measured using an anthropometric tape.

4. **Breadths** (cm): Bone breadths were measured with a sliding bone caliper at three sites—humerus bicondylar, bistyloid (wrist), and femur bicondylar.

   From these measures, Body Mass Index (BMI) was derived as weight (kg)/height² (m²).

Somatotype Assessment

The Heath–Carter method (Carter & Heath, 1990) was used to calculate somatotype ratings for each participant. The three components—endomorphy, mesomorphy, and ectomorphy—were derived from skinfolds, girths, bone breadths, and stature using standardized equations (Carter, 1996). Somatotype categories were expressed as mean values and compared between male and female groups.

Procedures

All measurements were conducted by certified anthropometrists with ISAK Level 1 accreditation to ensure accuracy and minimize technical error of measurement (TEM). Measurements were performed in a single session lasting approximately 15 minutes per participant. Equipment calibration was verified before testing sessions.

Statistical Analysis

All data were entered and verified before statistical analysis. Descriptive statistics (mean ± standard deviation) were computed separately for males and females. The normality of data was tested using the Shapiro–Wilk test, and homogeneity of variances was assessed with Levene's test. Based on these assumptions, either independent-samples t-tests or Mann–Whitney U tests were performed. All tests were two-tailed with $\alpha = 0.05$. Effect sizes were calculated as Cohen's d for independent-samples t-tests (Mesomorphy, Ectomorphy) and as rank-biserial correlation ($r_{(}rb_{)}$) for Mann–Whitney U tests (Endomorphy, BMI, Height, Weight). Ninety-five percent confidence intervals (CIs) were computed for all effect sizes to provide estimates of precision. Holm–Bonferroni correction was applied to control for multiple comparisons. Mann–Whitney U was chosen over Welch's t-test because it is robust to both non-normal distributions and unequal variances, and it allows for the use of rank-biserial correlation ($r_{(}rb_{)}$) as a consistent effect size measure across non-parametric comparisons.

Analyses were performed using two parallel platforms

Python (version 3.11; Python Software Foundation, Wilmington, DE, USA) with the NumPy, SciPy, and pandas libraries for inferential statistics, and Matplotlib for data visualization.

IBM SPSS Statistics (Version 27; IBM Corp., Armonk, NY, USA) for cross-validation of results using conventional sports science reporting practices.

Results

Descriptive Statistics

Fifty elite Kho-Kho players (25 males and 25 females) were analyzed for somatotype and anthropometric characteristics.

- **Endomorphy** was higher among females (M = 4.78 ± 1.52) compared to males (M = 3.67 ± 1.63).

- **Mesomorphy** was significantly greater in males (M = 3.50 ± 1.24) than in females (M = 2.32 ± 1.09).

- **Ectomorphy** was comparable across genders (males: M = 3.11 ± 1.38; females: M = 3.64 ± 1.35).

- Males exhibited greater height (172.4 ± 5.7 cm vs. 158.8 ± 5.8 cm), weight (64.6 ± 11.2 kg vs. 47.6 ± 6.6 kg), and BMI (21.7 ± 3.3 vs. 18.8 ± 2.2).

Table 1. Descriptive Statistics of Male and Female Elite Kho-Kho Players

Variable	Male (n = 25) Mean ± SD	Female (n = 25) Mean ± SD
Body Mass (kg)	64.64 ± 11.16	47.58 ± 6.63
Height (cm)	172.42 ± 5.66	158.80 ± 5.82
BMI	21.69 ± 3.27	18.84 ± 2.21
Endomorphy	3.67 ± 1.63	4.78 ± 1.52
Mesomorphy	3.50 ± 1.24	2.32 ± 1.09
Ectomorphy	3.11 ± 1.38	3.64 ± 1.35

Inferential Statistics

Normality checks and Levene's tests determined the choice of parametric or non-parametric analyses.

- **Endomorphy**: Females scored higher in endomorphy (M = 4.78, SD = 1.52) compared to males (M = 3.67, SD = 1.63). This difference was significant (U = 181, p = 0.011, Holm-adjusted p = 0.022, $r_{(rb)}$ = 0.42, 95% CI [0.10, 0.74]).

- **Mesomorphy**: Males had higher mesomorphy scores (M = 3.50, SD = 1.24) compared to females (M = 2.32, SD = 1.09). Inferential analysis confirmed this difference was significant (t = 3.58, p = 0.0008, Holm-adjusted p = 0.0024, Cohen's d = 1.01, 95% CI [0.42, 1.60]).

- **Ectomorphy**: Mean ectomorphy values were similar between males (M = 3.11, SD = 1.38) and females (M = 3.64, SD = 1.35). This difference was not statistically significant (t = −1.39, p = 0.171, Cohen's d = −0.39, 95% CI [−0.95, 0.17]).

- **Height**: Males were substantially taller (M = 172.42, SD = 5.66) compared to females (M = 158.80, SD = 5.82), a very large and significant difference (U = 603, p < 0.000001, Holm-adjusted p < 0.001, $r_{(rb)}$ = −0.93, 95% CI [−1.00, −0.61]).

- **Weight**: Males also weighed significantly more (M = 64.64, SD = 11.16) compared to females (M = 47.58, SD = 6.63), with a very large effect size (U = 579, p < 0.000001, Holm-adjusted p < 0.001, $r_{(rb)}$ = −0.85, 95% CI [−1.00, −0.53]).

- **BMI**: Males demonstrated higher BMI values (M = 21.69, SD = 3.27) than females (M = 18.84, SD = 2.21), a significant difference (U = 497, p = 0.00035, Holm-adjusted p = 0.0014, $r_{(rb)}$ = −0.59, 95% CI [−0.91, −0.27]).

These results indicate a clear sex dimorphism, with males demonstrating muscularity and skeletal robustness (mesomorphy), and females showing relatively greater adiposity (endomorphy).

Table 2. Inferential Statistics of Male and Female Elite Kho-Kho Players

| Variable	Test Used	Statistic	p-value	Holm-adjusted p	Effect Size	95% CI
Endomorphy	Mann–Whitney U	U = 181	0.011	0.022	$r_{(rb)}$ = 0.42	[0.10, 0.74]
Mesomorphy	t-test	t = 3.58	0.0008	0.0024	Cohen's d = 1.01	[0.42, 1.60]
Ectomorphy	t-test	t = −1.39	0.171	0.171	Cohen's d = −0.39	[−0.95, 0.17]
BMI	Mann–Whitney U	U = 497	0.00035	0.0014	$r_{(rb)}$ = −0.59	[−0.91, −0.27]
Height (cm)	Mann–Whitney U	U = 603	<0.000001	<0.001	$r_{(rb)}$ = −0.93	[−1.00, −0.61]
Weight (kg)	Mann–Whitney U	U = 579	<0.000001	<0.001	$r_{(rb)}$ = −0.85	[−1.00, −0.53]
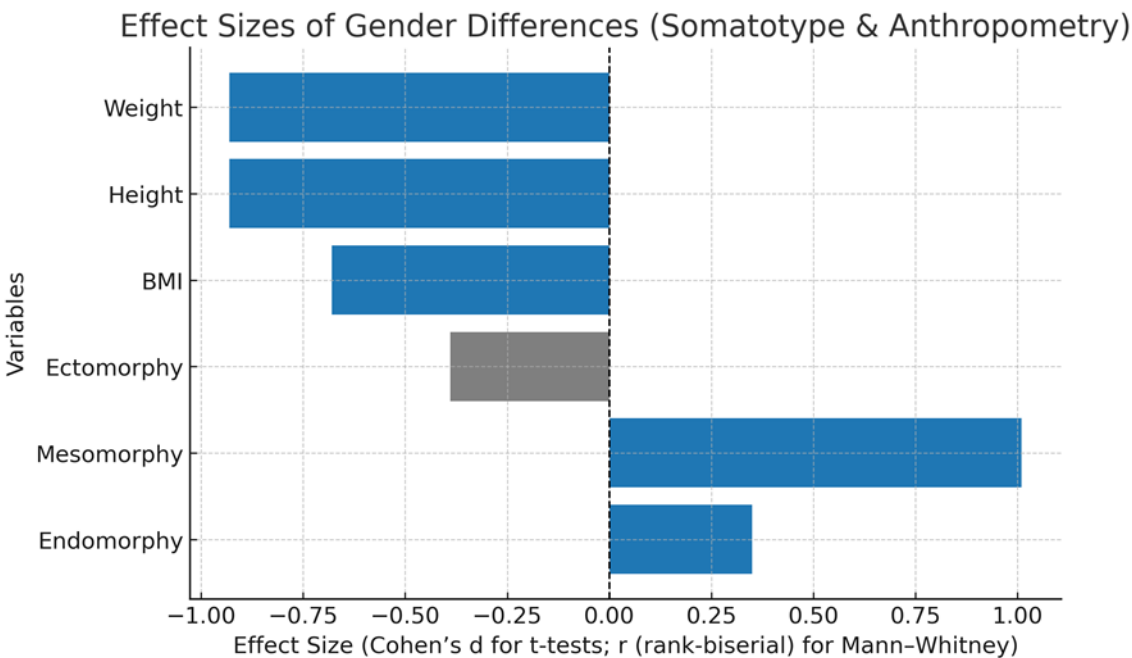
Figure 1. Effect sizes of gender differences across somatotype and anthropometric variables.

Positive values indicate the group with the higher mean: males for Mesomorphy (Cohen's d = +1.01) and females for Endomorphy ($r_{(rb)}$ = +0.42). Negative values indicate the opposite direction, such as lower female BMI, height, and weight (all $r_{(rb)}$ < 0) and higher female ectomorphy (Cohen's d = −0.39, non-significant). Effect sizes are expressed as Cohen's d for independent-samples t-tests (Mesomorphy, Ectomorphy) and as rank-biserial correlation ($r_{(rb)}$) for Mann–Whitney U tests (Endomorphy, BMI, Height, Weight). Blue bars denote statistically significant differences after Holm–Bonferroni correction (p < .05), and the gray bar denotes a non-significant difference.

Endomorphy was significantly higher in females (M = 4.78, SD = 1.52) compared to males (M = 3.67, SD = 1.63), while mesomorphy was significantly greater in males (M = 3.50, SD = 1.24) than females (M = 2.32, SD = 1.09). Ectomorphy did not differ significantly between groups (p = .171). These distributions are illustrated in violin-box plots. (See Figure 2)
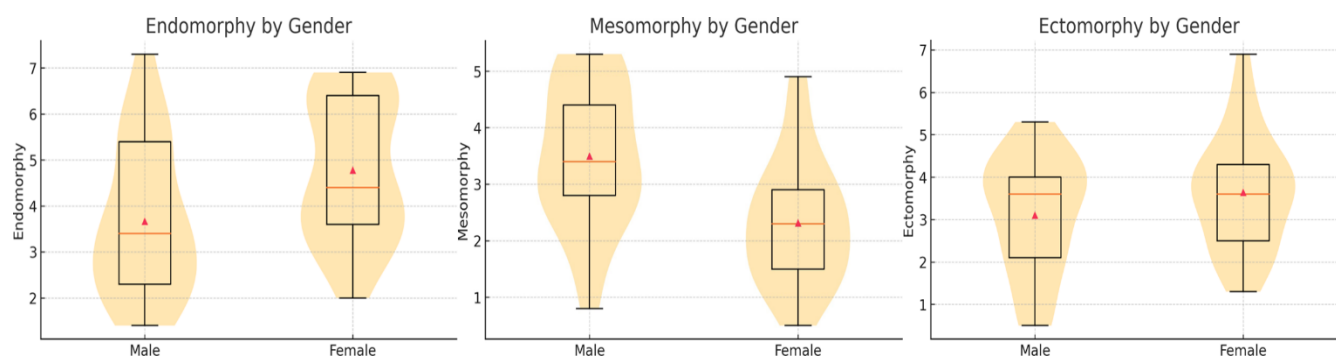
Figure 2. Violin-box plots of somatotype components (endomorphy, mesomorphy, ectomorphy) by gender.

*The black box represents the interquartile range (IQR), the orange line indicates the median, whiskers extend to minimum and maximum values excluding outliers, and red triangles denote mean values. (Figure.2). Violin-box plots showing the distribution of endomorphy, mesomorphy, and ectomorphy scores among male and female elite Kho-Kho players. Females show higher endomorphy values, consistent with significantly greater adiposity (U = 181, p = 0.011, Holm-adjusted p = 0.022; $r_{(rb)}$ = 0.42, 95% CI [0.10, 0.74]). Males display significantly higher mesomorphy, reflecting greater muscularity and skeletal robustness (t = 3.58, p = 0.0008; Cohen's d = 1.01, 95% CI [0.42, 1.60]). No significant gender difference was observed in ectomorphy, as indicated by overlapping distributions (t = −1.39, p = 0.171; Cohen's d = −0.39, 95% CI [−0.95, 0.17]).
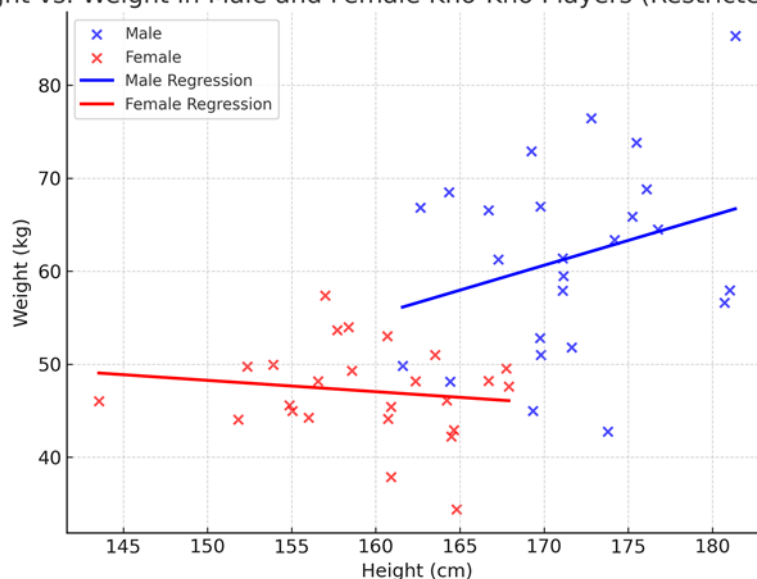

Figure 3. Scatterplot with regression lines for height and weight among male and female Kho-Kho players.

Height and weight differed significantly between genders, with males averaging taller (M = 172.42 cm) and heavier (M = 64.64 kg) than females (M = 158.80 cm, M = 47.58 kg). BMI was also significantly higher in males. The regression analysis of height vs. weight further highlights gender-specific proportionality. (See Figure 3)

Correlation analysis revealed that mesomorphy correlated positively with body weight and BMI, endomorphy correlated strongly with BMI, while ectomorphy showed negative associations with weight and BMI. These relationships are summarized in the correlation heatmap. (See Figure 4)

Somatotype distribution plotted on the somatochart demonstrated distinct gender-based clustering. Males tended to occupy the mesomorphic–ectomorphic zone, reflecting greater muscularity and leanness, while females clustered in the endomorphic–mesomorphic zone, suggesting higher fat deposition with moderate muscularity (see Figure 5).
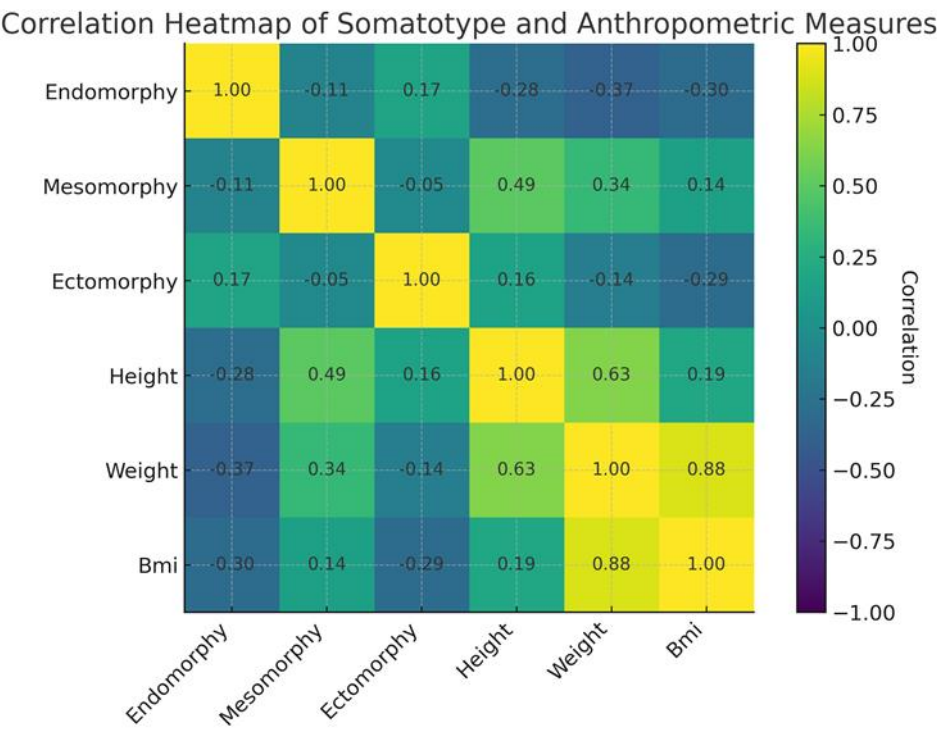
Figure 4. Correlation heatmap of somatotype components and anthropometric indices in elite Kho-Kho players.
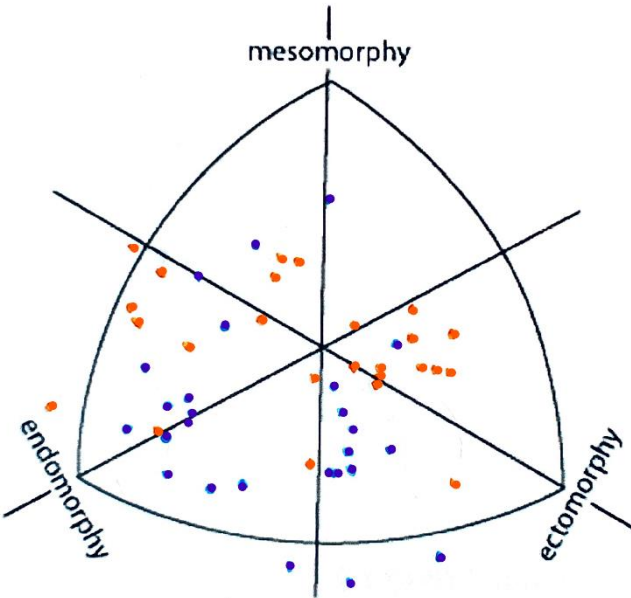

Figure 5. Somatochart depicting the distribution of male and female Kho-Kho players. *Orange – Male, Blue - Female

Discussion

The present study provides novel insights into the somatotype characteristics of elite male and female Kho-Kho players. Results confirmed significant gender differences, with males exhibiting higher mesomorphy and females demonstrating greater endomorphy, while ectomorphy was similar across groups. These findings align with established patterns of sexual dimorphism in physique and body composition, where males tend to develop greater muscularity and skeletal robustness, whereas females show relatively higher adiposity (Carter & Heath, 1990).

Our findings are consistent with prior research on indigenous Indian sports. Manohar (2015) reported that medalist Kho-Kho players demonstrated greater mesomorphy than non-medalists, underlining the importance of muscularity for success in this sport. Similarly, Ravinder and Kumar (2024) found strong correlations between anthropometric traits (e.g., height, leg length, girths) and performance indicators in Kho-Kho, emphasizing the physiological advantage of mesomorphic traits. The present study extends this evidence by highlighting that gender-specific somatotype differences are equally important in elite cohorts.

Comparisons with other sports further reinforce these findings. In Kabaddi, raiders typically show taller stature, longer arm span, and lower fat mass compared to defenders, reflecting role-specific somatotype adaptations (Dhanjal, 2024). Similarly, rowing and canoeing studies have documented sex-based morphological distinctions, with males clustering as balanced mesomorphs and females tending toward mesomorphic-endomorphs, a pattern associated with international performance disparities (Adhikari & Chakrabarti, 2022; Chakrabarti & Adhikari, 2023). In contrast, our results suggest that Kho-Kho demands both agility and endurance, thereby favoring mesomorphy in males while not penalizing endomorphic tendencies in females to the same extent.

Regional studies on female athletes provide additional context. Rickta et al. (2024) compared Bangladeshi Kho-Kho and football players, noting that Kho-Kho players had longer legs and better physique indices despite similar body fat percentages. Our findings complement this evidence, showing that although female Kho-Kho athletes carry higher endomorphy than males, their performance capacity may still be enhanced by specific skeletal and linear traits.

The absence of significant gender differences in ectomorphy indicates a shared trait of linearity (slimness) across sexes in Kho-Kho athletes. This is noteworthy, as ectomorphy contributes to agility and speed—core requirements of Kho-Kho. The combination of moderate ectomorphy and heightened mesomorphy in males likely provides a dual advantage for both strength and agility. Conversely, higher endomorphy among females may suggest a need for targeted conditioning interventions, such as strength training and fat reduction programs, to optimize competitive performance.

Conclusion

This study demonstrated clear gender-based somatotype differences among elite Kho-Kho players from Karnataka. Male players were characterized by greater mesomorphy, reflecting muscularity and skeletal robustness, while female players exhibited higher endomorphy, indicating greater adiposity. Ectomorphy did not differ significantly between genders, suggesting that both sexes share a similar degree of linearity. These findings highlight the role of sexual dimorphism in shaping athletic profiles and provide evidence that somatotype assessment can serve as a valuable tool for talent identification, training optimization, and performance monitoring in Kho-Kho.

Limitations

Several limitations should be acknowledged. First, the sample size, although elite, was limited to 50 national-level players, which may restrict generalizability to broader athletic populations. Second, the study employed a cross-sectional design, which prevents assessment of somatotype changes over time or in response to training cycles. Third, the analysis did not consider positional differences (e.g., chasers vs defenders), which may be associated with distinct morphological and physiological demands. Finally, environmental, dietary, and lifestyle factors, which can influence body composition, were not controlled for in this study.

Future Directions

Future research should build upon these findings by:

- Expanding sample sizes across different states and competitive levels to enhance external validity.

- Conducting longitudinal studies to monitor somatotype changes across training seasons, injury recovery, and competitive cycles.

- Exploring positional or role-specific somatotype requirements in Kho-Kho, similar to role-specific studies in Kabaddi and other team sports.

- Integrating physiological, biomechanical, and performance testing with somatotype profiling to provide a more holistic understanding of performance determinants.

- Investigating the effects of training and nutrition interventions designed to optimize body composition and performance, particularly in female athletes where higher endomorphy may be a limiting factor.

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Conflict of Interest

The authors declare that they have no conflicts of interest relevant to the content of this study.

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