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Sport performance levels and somatotype classifications in females

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Abstract

Background. The relationship between physique and athletic performance has been studied for decades, yet the relevance of somatotype compared to body composition indicators remains debated. This study aimed to examine morphological characteristics of female participants across different activity levels and to explore the extent to which somatotype and anthropometric traits differentiate performance groups.

Material and methods. A total of 118 females aged 18 to 35 years participated, including 38% high-performance athletes, 25% recreational athletes, and 36% physically less active individuals. Anthropometric measurements were obtained, and somatotypes were classified using the Heath-Carter method. Statistical analyses were conducted with SPSS 28.0, applying non-parametric tests due to non-normal data distribution.

Results. Somatotype distribution showed 36.4% endomorphic, 37.3% mesomorphic, 14.4% ectomorphic, and 11.9% central, with no significant association between somatotype and sport performance levels (χ^2=11.036, p=0.087). In contrast, significant differences were found in skinfold thickness (p=0.002) and waist circumference (p=0.009), with high-performance athletes exhibiting lower values than recreational and less active individuals. No significant variation was observed in humerus and femur condylus widths.

Conclusions. These findings suggest that body composition, rather than somatotype alone, plays a more relevant role in distinguishing performance levels, highlighting the importance of individualized, sport-specific assessments for training and talent identification.

Keywords: Heath-Carter method, body composition, anthropometry, physical activity, females

Introduction

The classification of human physique into systematic categories has long been a central topic in sport science and human biology. Anthropometric approaches aim to describe body structure and composition in a standardized manner, enabling comparisons across individuals and populations. One of the most widely applied frameworks is the Heath-Carter somatotype method, which characterizes physique using three numerical components representing endomorphy, mesomorphy, and ectomorphy, and remains a reference method in anthropometric research due to its reproducibility and practicality in field settings [1]. In contemporary sport science, somatotype and anthropometric assessments are frequently applied to support training optimization, talent identification, and the evaluation of physical readiness. However, recent research emphasizes that the relationship between somatotype classification and sport performance is complex and highly context dependent. Literature suggests that while certain somatotype profiles may be more prevalent in specific sports, performance outcomes are more strongly associated with detailed body composition parameters than with somatotype categories alone [2,3]. A recent scoping review indicates that female athletes often display central or mesomorphic-dominant somatotype profiles across a wide range of sports disciplines [4]. For instance, research on young female volleyball players has identified a dominant central somatotype, highlighting high musculoskeletal development and male-type body proportions, such as middle shoulders and long legs, which reflect the physical adaptations required for high-intensity jumping and agility in the sport [5]. These findings underline the importance of considering both sex-specific and sport-specific morphological demands when interpreting somatotype data. Studies in female and mixed athletic populations have shown that anthropometric traits related to adiposity and muscularity are closely linked to training status and performance level, even when somatotype categories remain similar across groups [6-8]. These findings support the notion that modifiable soft-tissue characteristics play a critical role in performance differentiation.

Methodological advances have also contributed to renewed interest in somatotype research. Recent investigations comparing traditional anthropometric methods with complementary techniques, such as bioelectrical impedance analysis, suggest that integrating multiple assessment approaches may improve the precision and interpretability of somatotype-related analyses, particularly in physically active female populations [9].

Despite the expanding literature, important gaps remain. Many studies focus on a single sport or compare only two performance categories, such as elite versus recreational athletes. Comparatively few investigations have examined female participants across multiple performance levels while simultaneously considering somatotype classification and detailed anthropometric traits. Addressing this gap may provide a more nuanced understanding of how morphological characteristics relate to sport participation and performance intensity in women. Therefore, the present study adopts a performance-level-based approach rather than a sport-specific framework.

Aim of the work

The present study analyzes morphological characteristics of female participants across high-performance, recreational, and physically less active groups. Our study is guided by the following research questions:

Q1: How do somatotype classifications differ across high-performance athletes, recreational athletes, and physically less active individuals?

Q2: What are the key anthropometric traits that differentiate sport performance groups?

Material and methods

Participants and ethics

This research employed an observational study design, focusing on anthropometric measurements within a specified population. Female participants aged 18-35 were recruited from three distinct groups: high-performance athletes, recreational athletes, and physically less active individuals. High-performance athletes, defined as those actively competing and affiliated with a national sports association, were recruited with the assistance of three sports organizations across two cities. Athletes represented heterogeneous samples from multiple sport disciplines. Sport disciplines were grouped according to their dominant physiological and technical demands and were analyzed descriptively only. Participants classified as physically less active did not report a regular sport discipline.

Contact with these athletes was facilitated by their coaches, who provided information about the study on a voluntary basis. Recreational athletes, those engaging in physical activities for leisure or fitness, and physically less active participants, defined as those engaging in fewer than 150 minutes of sport activities per week, were recruited through two higher education institutions using a centralized Student Electronic System. The sample size was based on practical feasibility and aligned with sample sizes used in similar published research on somatotype and competition levels.

Protocol

Participants provided information regarding their age and sports background, including the number of years they had been active in sports, their average weekly training hours, and their specific performance level. Performance levels were categorized as follows: competitive high-performance athletes at the national or international level with official membership in an association, or recreational athletes, whether competitive or non-competitive.

The Heath-Carter anthropometric somatotyping method was employed to classify participants based on their body composition. This method integrates a series of anthropometric

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measurements, including height and weight using SECA 703 scale (SECA GmbH & Co. KG), skinfold thickness at four sites (triceps, subscapular, supraspinale, medial calf) using the Harpenden skinfold caliper (HSB-BI, British Indicators Ltd., UK), bone breadths (biepicondylar humerus and femur) and limb circumferences (arm flexed and tensed, calf) to calculate three primary somatotype components: endomorphy, mesomorphy, and ectomorphy. For the calculation and interpretation, we used the equation given in the Heath-Carter Manual. Anthropometric measurements were conducted by a trained assessor following the international standards of the International Society for the Advancement of Kinanthropometry (ISAK) [10]. The applied anthropometric protocol and the Heath-Carter somatotyping method are widely used and have demonstrated acceptable validity and reliability in adult populations, including athletic samples [11,12]. Participants were classified into one of four somatotype categories based on their dominant component. Endomorphic individuals exhibit higher relative fat accumulation compared to muscularity or linearity. Mesomorphic individuals are characterized by predominant muscularity and well-developed skeletal dimensions. Ectomorphic individuals have slim, linear features with minimal muscularity. Central individuals display a balanced distribution of the three somatotype components without a clearly dominant type.

Data analysis

The statistical analyses were conducted using IBM SPSS Statistics software (version 28.0, IBM Corp., Armonk, NY, USA). A p-value of <0.05 was considered statistically significant. Data were presented as mean and standard deviation or frequency. Since most datasets did not meet the assumption of normality (Shapiro-Wilk test), non-parametric tests were applied. Group comparisons were performed using the Kruskal-Wallis test with post-hoc analysis, while categorical variables were analyzed using the Chi-square test.

Results

Participants

A total of 118 female participants were included in the study, with an average age of 22.27±3.71 years. Of the participants, 38% were high-performance athletes, 25% were recreational athletes, and 36% were physically less active individuals. The characteristics of participants based on their level of sports performance are presented in Table 1.

Table 1. Characteristics of participants based on their level of sport performance (n=118)

Mean (Standard Deviation) Proportions and percentages	High-performance athletes	Recreational athletes	Less active individuals
Sample size	45	30	43
Age (years)	21.69 (3.69)	22.37 (3.38)	22.81 (3.95)
Duration of sport activity (years)	14.12 (5.43)	12.35 (4.71)	–
Weekly training hours	14.86 (6.69)	5.64 (2.24)	–

Athletes represented heterogeneous samples from multiple sport disciplines (e.g. team sports, endurance sports, strength- and skill-based sports). Due to sample size constraints within individual disciplines, sport-specific subgroup analyses were not conducted. Results should be interpreted as reflecting general performance level rather than sport-specific morphological demands. Detailed distributions are presented in Table 2.

Table 2. Distribution of sport categories by performance level

Sport category	High-performance athletes n=45	Recreational athletes n=30
Team ball sports	33 (73.3%)	6 (20.0%)
Endurance/cyclic sports	11 (24.4%)	6 (20.0%)
Strength/combat sports	1 (2.3%)	–
Aesthetic/technical sports	–	4 (13.3%)
Conditioning/fitness	–	9 (30.0%)
Skill/mixed sports	–	2 (6.7%)
Other	–	3 (10.0%)

Somatotyping

According to the Heath-Carter somatotyping method, 36.4% of the participants were classified as endomorphic, 37.3% as mesomorphic, 14.4% as ectomorphic, and 11.9% as central. The Chi-square analysis revealed no statistically significant association between somatotype and sports performance (χ^2=11.036, df=6, p=0.087); however, the effect size, as measured by Cramer's V (V=0.216), suggests a small to medium association. When comparing the years spent in sports and weekly training hours across somatotypes, a statistically significant difference was initially found between the endomorph and ectomorph groups in weekly exercise time. However, after applying the Bonferroni correction, this difference was no longer statistically significant.

Anthropometric traits

Anthropometric parameters, including humerus and femur condylus widths, waist circumference, and the four skinfold thicknesses used in Heath-Carter somatotyping, were compared across different levels of sports performance. The results indicated that high-performance athletes generally exhibited more favorable anthropometric profiles in most parameters compared to their physically less active counterparts. No significant differences were found between the three groups in humerus and femur condylus widths. Recreational athletes were positioned between high-performance athletes and physically less active individuals. A significant difference in skinfold thickness was observed between recreational and high-performance athletes (p=0.002), with a medium effect size (η^2=0.218). Additionally, waist circumference differed significantly across all three groups, with post-hoc comparisons indicating significance at both p<0.001 and p<0.01 levels (Figures 1 and 2).

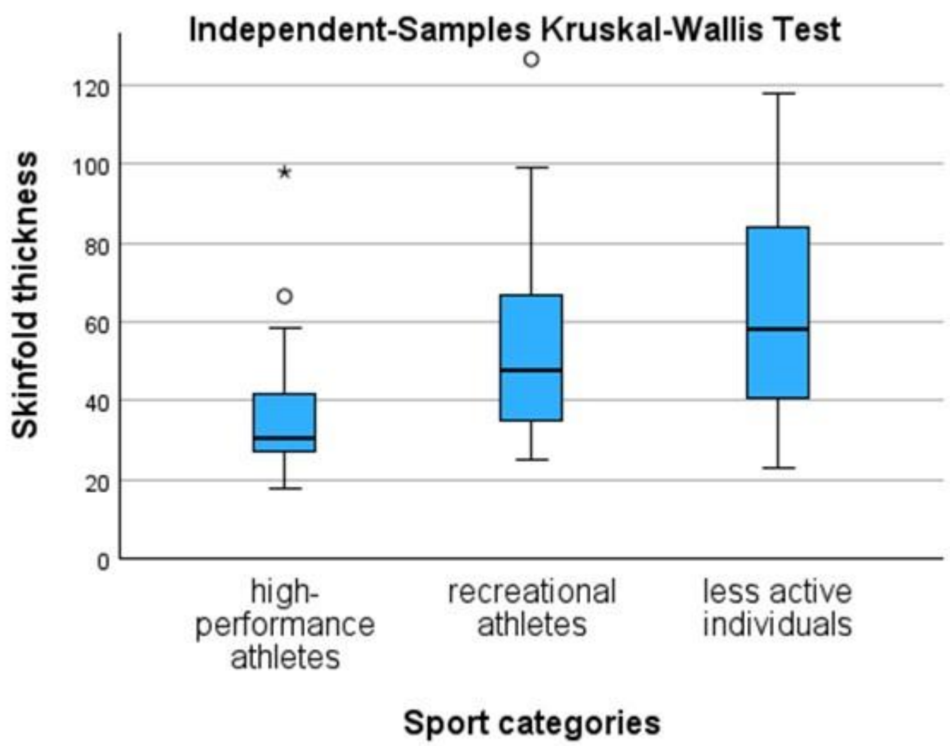

Figure 1. Post-hoc test results on sum of skinfold thickness across levels of sports performance (F=16.012; p<0.001)

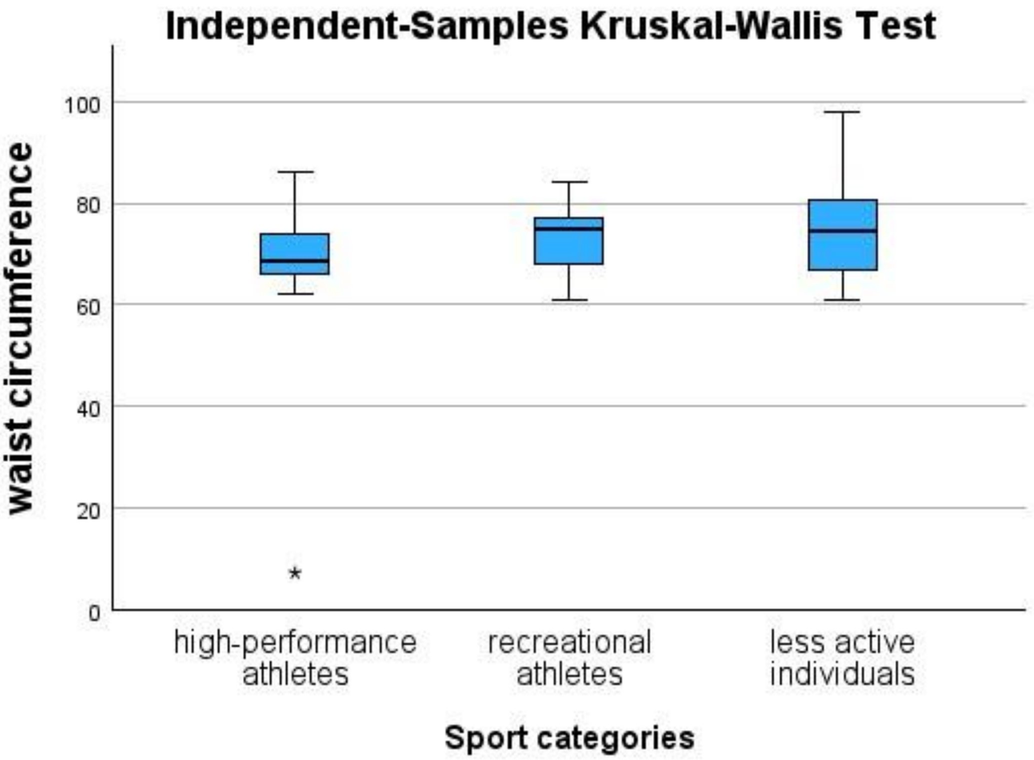

Figure 2. Post-hoc test results on waist circumference across levels of sports performance (F=4.963; *p*=0.009)

Discussion

This study investigated the morphological characteristics of female participants across three levels of physical activity and examined how somatotypes and anthropometric traits vary among our study groups. The results indicated no statistically significant association between somatotype categories and physical activity levels. According to the Heath-Carter method, mesomorphic and endomorphic somatotypes were the most prevalent within the sample, regardless of performance group. Previous research has reported similarly limited or inconsistent associations between somatotype classification and sport performance across various disciplines [13]. Contemporary studies in diverse female and mixed athletic populations have shown that body composition and specific anthropometric traits are more sensitive indicators of performance than broad somatotype classifications [2,6]. For instance, Ruscello et al. demonstrated that elite breaking athletes exhibited morphologic profiles closely aligned with sport-specific demands, independent of somatotype category [14]. Similarly, Baranauskas et al. found that muscle mass distribution and fat accumulation patterns were stronger predictors of competitive success than somatotype per se [15]. These observations are further supported by Toskic et al., who emphasized that the regularity of physical activity is the most crucial factor for improving body composition status. Their findings demonstrate that systematic training leads to a decrease in body fat and an increase in muscle mass and protein components regardless of the initial somatotype category, with endurance-specific activities having the most significant impact on fat reduction [16]. These results highlight that modifiable soft-tissue characteristics respond more clearly to training and performance requirements than skeletal dimensions. Our findings corroborate this contemporary perspective. The high-performance athletes in our sample displayed significantly lower skinfold thickness values and smaller waist circumferences compared with recreational and physically less active participants, whereas skeletal dimensions, such as humerus and femur condylus widths, did not differ significantly between groups. This pattern is consistent with recently established ISAK-based anthropometric standards for elite performers, which emphasize that sport-specific adaptations are primarily reflected in body composition and soft-tissue distribution rather than skeletal frame [17]. Comparable results have been reported in sport-specific contexts. In a study comparing elite climbers, recreational climbers, and non-climbers, Novoa-Vignau et al. observed that somatotype categories did not clearly differentiate performance levels, whereas differences in body composition and selected anthropometric characteristics were evident across groups [18].

These results align with Esteve-Ibáñez et al., who reported that body composition profiles among elite and non-elite orienteering athletes reflected both physical activity level and nutritional habits rather than somatotype classification alone [19].

A scoping review by Martínez-Mireles et al. further supports this interpretation, demonstrating that somatotype distributions vary widely across sports and between sexes, but performance differentiation is often better explained by specific anthropometric and body composition measures [4]. In line with these findings, Kamath et al. and Pérez Armendáriz et al. observed that female combat and track-and-field athletes with similar somatotype categories differed in muscle mass, fat distribution, and overall anthropometric profiles, which more accurately reflected performance outcomes [3,6].

Overall, these results underscore the influence of sport-specific physiological demands and the adaptations resulting from long-term, targeted training. High-performance athletes tend to develop morphological adaptations that reflect the metabolic, strength, and endurance requirements of their discipline. Such adaptations manifest more clearly in modifiable characteristics, such as fat distribution and muscle mass, than in fixed skeletal dimensions.

Consequently, individualized anthropometric assessment appears to offer more practical and precise guidance for athlete monitoring, development, and talent identification than reliance on generalized somatotype classifications, which may obscure significant intra-category variability in body composition [20].

Strengths and limitations

This study has several strengths. It provides a comprehensive comparison across three performance levels, enabling a more accurate characterization of the physical differences associated with varying levels of physical activity. By employing the validated Heath-Carter anthropometric method, it ensures reliable somatotype classification through detailed measurements. Importantly, the study addresses a notable gap in literature by focusing exclusively on female participants, an often underrepresented population in somatotype and performance research. The findings also have potential applied relevance, supporting individualized approaches in athlete monitoring and talent identification, moving beyond simplistic typological models. However, several limitations should be noted. The sample size of female participants may limit the generalizability of the findings to wider populations, including male athletes or individuals from different regions. The cross-sectional design restricts the ability to infer long-term training adaptations or developmental trends. Additionally, sport-specific physical demands were not fully accounted for, and potential confounding factors, such as nutrition, genetics, and hormonal variations, were not controlled, all of which may influence both somatotype and anthropometric outcomes.

Conclusions

This study showed that somatotype classifications were present across all performance levels, but no significant association with sport performance was found. In contrast, body composition indicators, such as skinfold thickness and waist circumference, differed significantly among the groups, with high-performance athletes exhibiting leaner profiles. Skeletal widths (humerus and femur condylus) did not differ significantly, suggesting that fixed bone structure is less relevant for distinguishing athletic performance. These findings reinforce that body composition and other modifiable anthropometric traits provide more meaningful insight into performance differences than somatotype classifications. Accordingly, individualized anthropometric assessment may offer greater practical value in training, athlete development, and talent identification.

Practical applications and future research

The present findings indicate that the general performance level in female participants is more closely associated with body composition characteristics than with somatotype classification alone. From a practical perspective, this suggests that coaches and practitioners should prioritize individualized anthropometric and body composition assessments rather than relying solely on somatotype-based profiling, particularly in heterogeneous sport samples. Future research should aim to examine sport-specific samples with larger subgroup sizes and employ longitudinal designs to better understand how training-related changes in anthropometric characteristics relate to performance development over time.

Disclosures and acknowledgements

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Ethical approval for the study was granted by the Regional Scientific and Research Ethics Committee under the approval number BORS-15/2023. Before completing the questionnaire, participants were provided with detailed information about the purpose and procedures of the study. They were assured that their participation was voluntary, their data would remain anonymous, and they had the option to withdraw at any time. Written informed consent was obtained from the participants.

Artificial intelligence (AI) was not used in the creation of the manuscript.

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