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Anthropometric characteristic, somatotype, and body composition of Indian Female Combat Sport Athletes: A comparison between Boxers, Judokas, and Wrestlers

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Resumen

Introducción: El objetivo de este estudio fue: 1) analizar las características antropométricas de las atletas de combate indias y 2) determinar y comparar el somatotipo específico del deporte (boxeo, judo y lucha libre) de las atletas de combate indias. **Método:** Noventa y nueve atletas de deportes de combate de nivel nacional (40 boxeadoras, 25 judocas y 34 luchadoras que competían regularmente en competencias nacionales y/o internacionales participaron en el estudio. Se realizaron mediciones antropométricas de masa corporal, estatura, 7 sitios de pliegues cutáneos, 3 perímetros y 2 diámetros. También se calculó el somatotipo para todos los sujetos. Todas las mediciones se analizaron estadísticamente mediante un análisis de comparación por pares y se estudiaron las diferencias entre los grupos. **Resultados:** Se hallaron diferencias significativas entre el boxeo y el judo para el valor medio del IMC. El análisis de comparación por pares reveló diferencias significativas en el componente mesomorfo entre el boxeo y el judo (p = 0,001; 95% IC: -1,83 – -0,40) y entre el boxeo y la lucha libre (p = 0,001; 95 % IC: -1.69 – -0.39); así como también en el componente ectomorfo entre el boxeo y el judo (p = 0.009; 95% CI: 0.16 – 1.35) y entre el boxeo y la lucha libre (p = 0.007; 95% CI: 0.17 – 1.25). **Conclusión:** Existen diferencias significativas en las características antropométricas al analizar el somatotipo de las atletas de combate indias, estas podrían atribuirse a las demandas específicas de cada deporte. Los practicantes y entrenadores deben considerar los programas de entrenamiento específicos del deporte teniendo en cuenta las características antropométricas y el somatotipo de las atletas que participan en el boxeo, el judo y la lucha libre.

Palabras Clave: Composición Corporal, IMC, % de Grasa Corporal, Mujer

Abstract

Introduction: The aim of this study was:1) to ascertain the anthropometric characteristics of Indian female combat athletes and 2) to determine and compare the sport-specific (boxing, judo, and wrestling) somatotype of Indian female combat athletes. **Method:** Ninety-nine national level female combat sports athletes (40 Boxers, 25 Judokas, and 34 Wrestlers who regularly compete in national and/or international competitions, took part in the study. Anthropometric measurements were performed for body mass, stature, 7 skinfold sites, 3 girths, and 2 breadths. Somatotypes for all subjects were also calculated. All measurements were statistically analyzed using pairwise comparison analysis and differences between groups were also compared. **Results:** Significant differences between boxing and judo for the mean value of BMI. Pairwise comparison analysis revealed significant differences in the mesomorphy component between boxing and judo (p = 0.001; 95% CI: -1.83 – -0.40) and between boxing and wrestling (p = 0.001; 95% CI: -1.69 – -0.39); as well as in the ectomorphy component between boxing and judo (p = 0.009; 95% CI: 0.16 – 1.35) and between boxing and wrestling (p = 0.007; 95% CI: 0.17 – 1.25). **Conclusion:** There are significant differences in anthropometric characteristics when analyzing the somatotype of Indian female combat athletes which could be attributed to the specific demands of each sport. Sport-specific training programmes that consider the anthropometric characteristics and somatotype of female athletes participating in Boxing, Judo and Wrestling should be considered by practitioners and coaches.

Keywords: Body Composition, BMI, % of Body Fat, Women

Introduction

Combat sports such as judo, wrestling, and boxing are characterised by alternating periods of high-intensity actions and low-intensity intervals (Franchini et al., 2019; Vasconcelos et al., 2020) and rely heavily on both the aerobic and anaerobic metabolism to produce energy (Bridge et al., 2014; Franchini et al., 2011). Success in combat sports depends on various factors, such as technical-tactical, physical, physiological, and psychological performance (Franchini et al., 2019). In addition, it is well established that an athletes' body composition and somatotype plays a crucial role in overall performance (Franchini et al., 2007; Kim et al., 2011; Lewandowska et al., 2011).

Assessing body composition in combat athletes is fundamental for enhancing their athletic performance (Ackland et al., 2012; Malina, 2007). Research indicates that optimising body composition yields advantages in aerobic performance (Brun et al., 2011; Högström et al., 2012), strength (Granados et al., 2008; Silva et al., 2011), and overall health (Nattiv et al., 2007; Sundgot-Borgen et al., 2013). Anthropometric measures, such as body weight, skinfold thickness, circumferences, and body mass index (BMI), are commonly used to describe body composition (Shen et al., 2005). The relationship between body shape and composition can be assessed through somatotype classification, which categorises the physique based on measures of adiposity, musculoskeletal robustness, and linearity or slenderness (Ryan-Stewart et al., 2018). This classification system utilises three numbers that represent endomorphy, mesomorphy, and ectomorphy and expresses genetic determinism from a morpho-constitutional perspective (Lewandowska et al., 2011). In sports, somatotypes can aid in describing the physical characteristics of a population and assist with identifying talented athletes (Lewandowska et al., 2011).

Previous studies have reported on anthropometric characteristics and somatotype in wrestling (Ramirez-Velez et al., 2014; Sterkowicz-Przybycień et al., 2011), judo (Casals et al., 2017; Spieser et al., 2012) and boxing (Noh et al., 2014). However, most studies which have been published have focused on male athletes, with little research available on female counterparts. A study conducted by Reale et al. (2019) on Olympic female combat sport athletes reported body fat values of 13.9 % in boxers, 17.6 % in judokas and 14.8 % in wrestlers. A similar study by Smaruj et al. (2019) reported 23.6% of body fat and 4.2, 5.6 and 1.5 endomorph, mesomorph and endomorph, respectively, in female judokas. However, Casals et al. (2017) observed less percentage of body fat (17 %) in Spanish female senior judokas, while Spieser et al. (2012) found Swedish judokas to have 24.8 % of body fat and somatotypes of 2.2 of endomorph, 6.0 mesomorph and 2.2 of ectomorph. Regarding female wrestlers, Arakawa et al. (2020) studied Japanese wrestlers and observed that they have a mean of 18.2 % body fat, while Pallarés et al. (2012) analysed 35 female wrestlers and found a mean of 15.4 % of body fat. There is a paucity of research when it comes to Indian combat sport athletes.

Considering the importance of body composition and somatotype on overall performance (Franchini et al., 2007) there is a need to establish findings within the Indian female combat sport population. Many authors have empathised the importance of somatotype to identify and classify the sport specialisation (Sterkowicz-Przybycień et al., 2011). To the authors' knowledge, there is no previous study reporting on the anthropometric characteristics and somatotype of Indian female judokas, wrestlers, and boxers. Thus, the aim of this study was twofold: 1) to ascertain the anthropometric characteristics of Indian female combat athletes and 2) to determine and compare the sport-specific (i.e., boxing, judo, wrestling) somatotype of Indian female combat athletes.

Material and Methods

Subjects

Ninety-nine national level female combat sports athletes (40 boxers, 25 judokas, and 34 wrestlers; age 18.5 ± 2.9 yrs, body mass 57.5 ± 8.5 kg, body stature 160.5 ± 6.1 cm, and BMI 22.2 ± 2.4) volunteered to take part in this study. Only athletes who were associated with Inspire Institute of Sport (Vidyanagar, India) and regularly compete in national and/or international competitions were eligible to take part in the study. The study was part of the general sports science provision of the Institute and all the procedures used were reviewed and approved by the local ethics committee (EC/IIS/2023/007) and conformed to the recommendations of the Declaration of Helsinki.

Anthropometric Measurements

Anthropometric measurements were performed following the protocol developed by the International Society for The Advanced of Kinanthropometry (ISAK manual 2019). Anthropometric variables included body mass, stature, 7 skinfold sites ((biceps, triceps, subscapular, supraspinale, abdominal, front thigh, and medial calf), 3 girths (upper arm flexed, upper arm relaxed, and medial calf), and 2 breadths (humeral and femoral epicondyles). Stature was measured to the nearest 0.1 cm using a stadiometer (Holtain Ltd., Crymych, United Kingdom) and body mass to the nearest 0.1 kg using a calibrated weighing scale (Essae DS-215, Bangalore, India). Skinfold thickness was recorded

to the nearest 0.2 mm at a constant pressure of 10 g·mm−1 using a calibrated Holtain skinfold caliper (Holtain Ltd., Crymych, United Kingdom). Skinfolds were measured three times at each site in a rotation system, and a third measure was taken if required. Body fat (%) was estimated using standard equation (Siri 1956). Girths were determined to the nearest 0.1 cm using a flexible anthropometric tape (Anthroflex, Minneapolis, USA). All measurements were conducted by accredited ISAK L1 (RA) and ISAK L2 (SP) practitioners with a depth of experience in taking measures.

Somatotype

The Heath-Carter [1967] method was followed for somatotype rating. The following equations were used for calculating somatotype components.

Endomorphy = ─ 0.7182 + 0.1451 × ∑SF ─ 0.00068 × ∑SF 2+ 0.0000014 × ∑SF 3

where ∑SF = (sum of Triceps, Subscapular and Supraspinale skinfold) multiplied by (170.18/Height in cm).

Mesomorphy = 0.858 × Humerus breadth + 0.601 × Femur breadth + 0.188 × corrected Arm girth + 0.161 × corrected Calf girth ─ Height × 0.131 +4.5

Three different equations are used to calculate Ectomorphy according to the height -weight ratio (HWR):

1) If HWR is greater than or equal to 40.75 then, Ectomorphy = 0.732 × HWR ─ 28.58
2) If HWR is less than 40.75 and greater than 38.25 then, Ectomorphy = 0.463 × HWR ─ 17.63
3) If HWR is equal to or less than 38.25 then, Ectomorphy = 0.1

Statistical Analysis

Data are presented as the mean ± SD and the Statistical Package for the Social Sciences (SPSS), version 26, for Windows were used. To determine the differences in somatotype components between sports, a one-way ANOVA was performed. Assumptions of ANOVA, including normality and homogeneity of variances, were checked and met. Tukey's HSD test was used as a post-hoc test to further identify which specific sports differ significantly from each other. The level of significance was set to $p \leq 0.05$.

Results

Table 1 presents the descriptive statistics of demographic data (age, height, weight, BMI), anthropometric measurements (skinfolds, girths, breadths, height-weight ratio, sum of skinfolds), somatotype body components (endomorph, mesomorph, ectomorph) and percent body fat among female athletes participating in boxing, judo, and wrestling in India. Table 2 and Table 3 provide an inferential statistical analysis comparing somatotype components across the different sports. Figures 1, 2, and 3 illustrate the individual positions of each athlete on the somatotype chart, while Figure 4 depicts the mean values for each sport.

The pairwise comparison analysis for anthropometrics characteristics revealed significant differences between boxing and judo for the mean value of BMI (p = 0.025; 95% CI: -3.04 – -0.18), and subscapular skinfold (p = 0.038, 95% CI: -5.91 – -0.14). Additionally, it indicated a significant difference between boxing and judo for mean values of biceps skinfold (p = 0.046, 95% CI: 0.02 – 2.70), relaxed arm girth (p = 0.001; 95% CI: -4.02 – -0.95), flexed arm girth (p = 0.003, 95% CI: -3.70 – -0.64), height- weight ratio (p = 0.014; 95% CI: 0.18 – 1.95) and also among boxing and wrestling for mean values of biceps skinfold (p = 0.008; 95% CI: 0.35 – 2.81), relaxed arm girth (p = 0.001; 95% CI: -3.80 – 1.00), flexed arm girth (p = 0.008; 95% CI: -3.20 – -0.40), height- weight ratio (p = 0.014; 95% CI: 0.17 – 1.79). Moreover, there is a significant difference between judo and wrestling for mean value of medial calf skinfold (p = 0.028; 95% CI: 0.25 – 5.36).

Table 1. Descriptive statistics for the variables by sport group and overall.

Parameters	Boxing (n = 40) M (SD)	Judo (n = 25) M (SD)	Wrestling (n = 34) M (SD)	Total (n = 99) M (SD)
Demographics				
Age (Years)	18.56 (3.29)	18.50 (3.11)	18.30 (2.40)	18.45 (2.94)
Height (cm)	161.62 (5.90)	161.50 (6.64)	158.43 (5.59)	160.49 (6.12)

Weight (kg)	56.29 (8.95)	60.51 (9.27)	56.57 (6.73)	57.45 (8.45)
BMI (kg/m^2)	21.50 (2.69)^b	23.10 (2.38)^a	22.49 (1.88)	22.24 (2.43)
Body Fat (%)	15.76 (3.88)	16.10 (3.88)	15.27 (3.00)	15.68 (3.58)
Skinfolds				
Triceps (mm)	13.20 (4.74)	12.31 (4.21)	11.87 (4.13)	12.52 (4.40)
Subscapular (mm)	10.54 (4.18)^b	13.56 (4.81)^a	12.27 (5.33)	11.90 (4.87)
Biceps (mm)	6.52 (2.83)^{bc}	5.15 (2.12)^a	4.93 (1.24)^a	5.63 (2.31)
Supraspinale (mm)	9.99 (4.05)	9.40 (4.23)	8.58 (2.88)	9.36 (3.75)
Abdominal (mm)	14.41 (5.23)	12.71 (3.91)	13.77 (4.38)	13.76 (4.64)
Front Thigh (mm)	19.14 (6.11)	20.51 (5.73)	19.41 (8.05)	19.58 (6.71)
Medial Calf (mm)	11.41 (4.50)	12.38 (5.09)^c	9.58 (2.39)^b	11.03 (4.19)
Sum of Skinfolds (mm)	78.69 (25.08)	80.87 (25.07)	75.49 (19.41)	78.14 (23.14)
Girths				
Arm Relaxed (cm)	26.53 (2.63)^{bc}	29.02 (2.68)^a	28.94 (2.28)^a	27.99 (2.78)
Arm Flexed (cm)	28.60 (2.80)^{bc}	30.77 (2.56)^a	30.39 (2.12)^a	29.76 (2.68)
Calf (cm)	32.80 (4.31)	34.82 (3.10)	33.67 (2.30)	33.61 (3.49)
Breadths				
Humerus (cm)	5.92 (0.56)	6.00 (0.39)	5.98 (0.68)	5.96 (0.57)
Femur (cm)	8.64 (0.88)	9.12 (0.55)	8.70 (0.94)	8.78 (0.85)
Ratio				
Height Weight Ratio (HWR)	42.34 (1.75)^{bc}	41.27 (1.27)^a	41.36 (1.18)^a	41.73 (1.53)
Body Components				
Endomorphy	3.57 (1.22)	3.73 (1.14)	3.54 (1.00)	3.60 (1.12)
Mesomorphy	3.82 (1.27)^{bc}	4.94 (0.98)^a	4.86 (1.17)^a	4.46 (1.27)
Ectomorphy	2.45 (1.20)^{bc}	1.70 (0.79)^a	1.74 (0.79)^a	2.02 (1.04)

Note: M = Mean; SD = Standard Deviation. a, b, c = significantly different to boxing, judo, wrestling respectively.

Similarly, pairwise comparison analysis revealed significant differences in the mesomorph component between boxing and judo (p = 0.001; 95% CI: -1.83 – -0.40) and between boxing and wrestling (p = 0.001; 95% CI: -1.69 – -0.39). Moreover, significant differences were found in the ectomorph component between boxing and judo (p = 0.009; 95% CI: 0.16 – 1.35) and between boxing and wrestling (p = 0.007; 95% CI: 0.17 – 1.25). However, non-significant differences were observed in the endomorph component for each sport.

Table 2. ANOVA table with statistical significance (p<0.05) in **bold.**

		Sum of Squares	df	Mean Square	F	sig.
Endomorphy * Sport	Between Groups (Combined)	0.544	2	0.272	0.214	0.808
	Within Groups	122.010	96	1.271		
	Total	122.554	98			
Mesomorphy * Sport	Between Groups (Combined)	27.394	2	13.697	9.988	**0.000**
	Within Groups	131.654	96	1.371		
	Total	159.048	98			
Ectomorphy * Sport	Between Groups (Combined)	12.687	2	6.344	6.591	**0.002**
	Within Groups	92.393	96	0.962		
	Total	105.080	98			

Note: df = degree of freedom; sig = significance

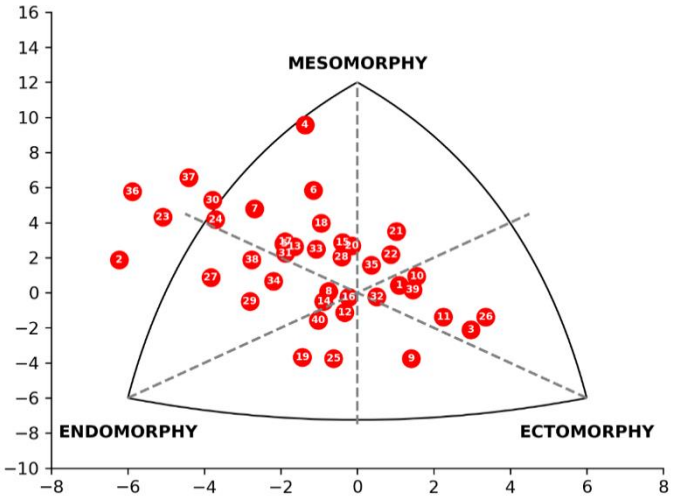

Figure 1. Somatoplot of Female Boxers

Table 3. Multiple Comparisons (Tukey HSD) comparing somatotypes and sport.

Dependent Variable	(I) Sport	(J) Sport	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Endomorphy	Boxing	Judo	-0.156	0.287	0.850	-0.841	0.528
		Wrestling	0.027	0.263	0.994	-0.599	0.653
		Boxing	0.156	0.287	0.850	-0.528	0.841
	Judo	Wrestling	0.183	0.297	0.812	-0.524	0.890
		Boxing	-0.027	0.263	0.994	-0.653	0.599
	Wrestling	Judo	-0.183	0.297	0.812	-0.890	0.524
	Boxing	Judo	-1.115*	0.299	**0.001**	-1.826	-0.404
Mesomorphy		Wrestling	-1.038*	0.273	**0.001**	-1.688	-0.387
	Judo	Boxing	1.115*	0.299	**0.001**	0.404	1.826
		Wrestling	0.077	0.309	0.966	-0.657	0.812
	Wrestling	Boxing	1.038*	0.273	**0.001**	0.387	1.688
		Judo	-0.077	0.309	0.966	-0.812	0.657
	Boxing	Judo	0.754*	0.250	**0.009**	0.159	1.350
Ectomorphy		Wrestling	0.710*	0.229	**0.007**	0.165	1.255
	Judo	Boxing	-0.754*	0.250	**0.009**	-1.350	-0.159
		Wrestling	-0.044	0.258	0.984	-0.659	0.571
	Wrestling	Boxing	-0.710*	0.229	**0.007**	-1.255	-0.165
		Judo	0.044	0.258	0.984	-0.571	0.659

* The mean difference is significant at the .05 level

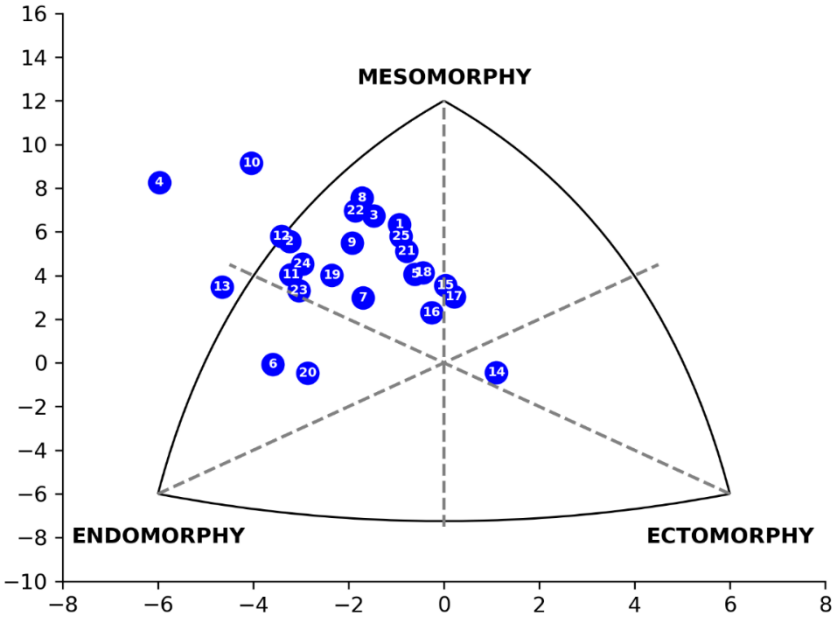

Figure 2. Somatoplot of female judokas

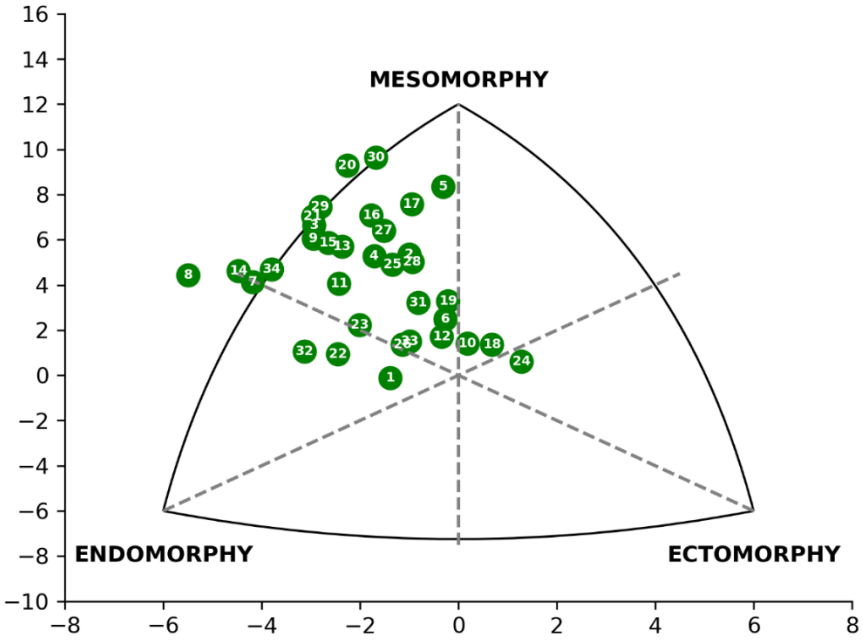

Figure 3. Somatoplot of female wrestlers

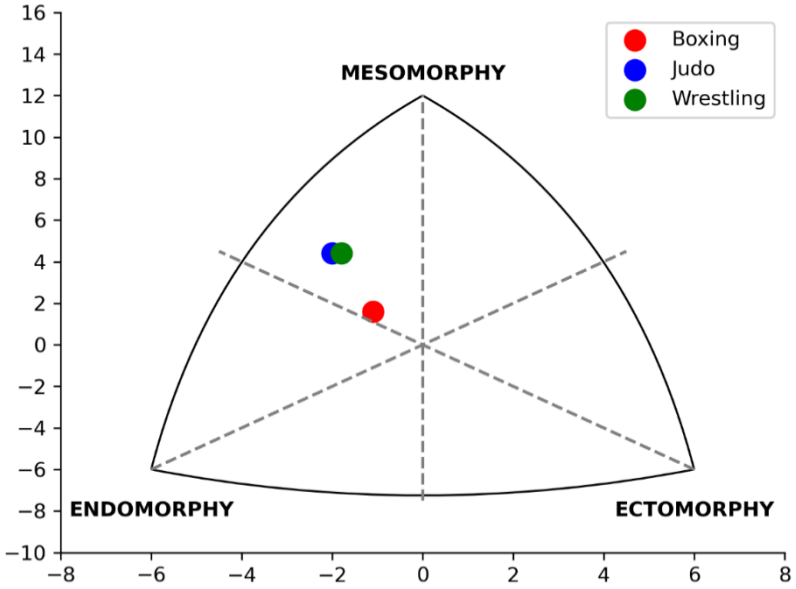

Figure 4. Somatoplot comparison between female boxers, judokas, and wrestlers

Discussion

The primary aim of this study was to describe the anthropometric characteristics of Indian female combat athletes. Secondly, we aimed to determine and compare the female somatotype of each combat sport (boxing, judo, and wrestling). This study shows the anthropometric characteristics of each athlete and the findings revealed that the mesomorph and ectomorph components have significant differences in judo and wrestling when compared with boxing (Table 1, Table 2, Table 3).

It was observed that judokas tend to have a higher BMI compared to boxers. In terms of skinfolds, the high subscapular skinfold value suggests that judokas may have a higher proportion of fat in these areas of the body compared to boxers. As for the bicep skinfold, it was higher in boxing compared to judo and wrestling, while, in the measurement of the calf skinfold, lower values were observed in wrestling compared to boxing and judo (Table 1). As for the circumferences, higher values were found for the circumference of the relaxed and flexed arm in judo and wrestling compared to boxing. These differences may be due to differences in the physical demands of each sport, while boxing is characterized by punching and agility movements (Thomson & Lamb, 2016), judo and wrestling are characterized by grappling (pushing and pulling) actions (Martin & Margherita, 1999; Miarka et al., 2012), which could affect the total amount and distribution of muscle mass and fat in the body (Reale et al., 2020). These results could be useful in understanding the characteristics and differences between Indian female combat athletes and international peers. However, further anthropometric studies on Indian athletes that differentiate between different weight categories are needed.

In relation to body fat, it has been revealed that Indian female combat athletes all were found to have similar % (boxing = 15.76 ± 3.88 %; judo = 16.10 ± 3.88 %; wrestling = 15.27 ± 3.00 %). These values are in line with previous studies assessing the body composition of athletes from these sports (Reale et al., 2020; Casals et al., 2017; Pallares et al., 2012). However, some studies observed body fat % values to be ~8% higher for judokas (Smaruj et al., 2019; Spieser et al., 2012), and ~3% higher for wrestlers (Arawaka et al., 2020). There are several factors that may contribute to the observed variations in the fat percentage such as contextual (e.g., nutrition, menstrual cycle, training, ethnicity), inter-rater reliability of the assessors, and the weight category for competition. Body fat percentage is a critical factor that requires consideration and regulation for women in weight category sports due to its influential role in determining performance and overall health.

The results show significant differences in mesomorphy and ectomorphy components when comparing judo and wrestling with boxing. Judo and wrestling athletes exhibit higher levels of mesomorphy than boxers, which may suggest that a more muscular build is advantageous in wrestling-oriented sports (Table 2, Figure 1, 2, 3, & 4). Previous researches have observed a greater predominance of the mesomorphic and endomorphic component over the ectomorphic component in Wrestling and Judo (Ramirez-Velez et al., 2014; Smaruj et al., 2019; Spieser et al., 2012). In contrast, Boxers show higher levels of ectomorphy, which could imply that a leaner physique may be more

advantageous for boxing's emphasis on speed and agility, although this characteristic seems to depend on the weight category (Noh et al., 2014). Significant differences in body types between sports could have implications for talent identification and training strategies (Reale et al., 2020). Understanding the somatotype associated with each sport could help optimize training methods and strategies to meet the specific demands of each discipline.

The present study is limited by sample size, and more research with more athletes is warranted. Moreover, the weight categories (i.e., heavy-weight, medium-weight, low-weight) were not considered, which could have influenced the results and provided a better understanding of the specific somatotype across each sport and category. Lastly, contextual factors (i.e., menstrual cycle, hydration, nutrition, exercise) were not reported, which may affect the results. Nevertheless, this is the first study to analyze the anthropometric characteristics and compare the somatotype of female Indians across three different combat sports (i.e., boxing, judo, and wrestling).

In conclusion, anthropometric characteristics differ among Indian female combat sport athletes, this could be attributed to the specific demands of the sport. Consequently, there are significant differences in mesomorphy and ectomorphy components when comparing judo and wrestling with boxing when analyzing the somatotype of Indian female combat athletes.

Practical Applications

Coaches and physical trainers can use this information to design sport-specific training programs that consider the anthropometric characteristics and somatotypes of female athletes participating in Boxing, Judo, and Wrestling. In addition, these findings may be valuable for talent identification and contribute to the development of female combat athletes. Finally, Sports scientists and researchers can build on these results to conduct further anthropometric studies covering larger sample sizes considering the weight categories within each sport.

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