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Sport-Specific Anthropometry and Body Composition in Nicaraguan Athletes at the Paris 2024 Olympics

Antropometría y Composición Corporal Específicos por Deporte en Atletas Nicaragüenses en los Juegos Olímpicos París 2024

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SUMMARY: Anthropometric characteristics and body composition significantly influence elite sports performance. However, data on Olympic athletes remains limited. This cross-sectional study aimed to determine the anthropometric characteristics and body composition of Nicaraguan athletes who participated in the 2024 Paris Olympic Games. Four female athletes (100-meter sprint, shortboard surfing, shooting, and short rowing) and one male athlete (400-meter butterfly swimming) participated in this case study. Measurements included 8 skinfolds, 13 girths, 9 lengths/heights, and 9 bone diameters, all assessed using calibrated Holway instruments following ISAK protocols. Data were processed through ISAKMetry software for body composition and somatotype analysis. The male swimmer exhibited the highest body mass (82.8 kg), height (183 cm), and wingspan (192.4 cm; relative span index: 105.1 %), while the shooter was the shortest (160 cm). Body fat percentage ranged from 18.2 % (swimmer) to 30.4 % (surfer), with the sprinter showing the lowest value among females (24.8 %). Muscle mass percentage varied from 41.4 % (surfer) to 53.7 % (shooter). Key indices revealed optimal muscle-to-bone (4.5) and fat-to-muscle (0.3) ratios in the shooter. The somatotypes found in the disciplines were: in athletics (100 m): mesomorphic ectomorph(1.8-3.0-3.7); Surfing: endomorphic mesomorph (3.0-3.6-2.3); Swimming: mesomorph endomorph (3.4-3.7-2.8); Shooting: ectomorphic mesomorph (1.5-4.9-3.2); Rowing: endomorphic mesomorph (3.4-5.5-1.5). These findings highlight distinct morphological patterns aligned with sport-specific demands, providing valuable reference data for talent identification and training optimization in elite Nicaraguan athletes.

KEY WORDS: Anthropometry; Body composition; Athletic Performance; Somatotypes; Sports; Adipose Tissue.

INTRODUCTION

Olympic athletes represent a unique subset among high-performance athletes, as they follow rigorous training regimes to achieve the top spot on the world podium every four years, adhering to a strict training regime that considers physical, nutritional, and psychological aspects (Giovanelli *et al*., 2024). In the ongoing monitoring and control of elite athletes, body composition assessment can help monitor the quality of training programs in the quest to optimize competitive performance, depending on the specific sport (Baranauskas *et al*., 2024; Martín-Rodríguez *et al*., 2024).

The International Society for the Advancement of Kinanthropometry (Norton & Olds, 2006) has developed international standards for anthropometric comparison.

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Using this technique and reference values, skinfold thickness, circumferences, and bone width can be measured to obtain analytical elements within kinanthropometry, such as body composition or somatotype of athletes, from training stages to peak performance. This allows each athlete to be compared with themselves (their evolution) and with the most successful athletes in their sport (Herrera-Amante *et al*., 2025a,b).

Body composition, which refers to the proportion of fat, muscle, and bone in an athlete, is a critical factor in athletic performance. An athlete's body composition phenotype reflects the complex interaction between genotypes, the physiological and metabolic demands of sport, diet, and physical training (Campa *et al*., 2021; Lukaski & Raymond-Pope, 2021). Therefore, traditional anthropometric assessment approaches should be supplemented with innovative methods that consider the identification of total and regional body composition characteristics (e.g., arms, legs, trunk) associated with sport-specific performance (Lukaski, 2017).

From an operational perspective, skeletal muscle mass (FFM) represents functional mass and contributes positively to strength production, thereby enhancing athletic performance (Campa *et al*., 2021). Conversely, fat mass (FM) is considered non-functional mass, and increasing amounts of FM mechanically and metabolically hinder athletic performance (Garrett & Kirkendall, 2000). Therefore, greater lean mass and higher bone mineral density are characteristics that favor greater expression of muscle strength and power (Schipilow *et al*., 2013; Stock *et al*., 2017), while athletes with lower fat mass can better withstand exertion than individuals with more non-functional mass due to a lower relative workload and, potentially, a more efficient thermoregulatory system (Herrera-Amante *et al*., 2025a,b).

Within biotypology, the study of human types based on morphological, physiological, and psychological characteristics, body physique, which encompasses size, structure, and body composition, plays a crucial role in sports science and health, influencing athletic performance and overall physical fitness (Martínez-Mireles *et al*., 2025). In this vein, somatotype involves anthropometric measurements such as skinfold thickness, circumference measurements and bone diameters to generate a three-number score representing the relative predominance of each component of the somatotype, categorizing body physiques into the components of endomorphy, mesomorphy and ectomorphy, prioritizing body shape and composition over size (Campa *et al*., 2021; Martínez-Mireles *et al*., 2025). According to various studies, somatotype is considered a determining factor in athletic performance (Cinarli *et al*., 2022). For example, in terms of somatotype values and explosive strength, it was observed that an increase in the endomorphy value had a negative effect on vertical jump performance, which assessed the change in the position of the center of mass with respect to gravity. In contrast, an increase in ectomorphism had a positive effect on vertical jump and sprint performance (Kutseryb *et al*., 2017). Additionally, ectomorphic components have been shown to improve aerobic capacity in endurance sports (Herrera-Amante *et al*., 2025a,b).

On the other hand, there has been interest in studying whether certain body types confer an advantage in different types of sports and/or constitute an important indicator for identifying potential success (Torres-Unda *et al*., 2013), considering height, for example, in sports such as basketball. In addition to height, a large arm span (also known as reach or arm length) is considered important for athletic success (McCauley, 2018). These groups of athletes compete in sports where a large arm span is highly valued, representing both team sports (such as basketball) and individual sports (like mixed martial arts) (Monson *et al*., 2018), as well as traditional rowers (León-Guereño *et al*., 2018). Therefore, the aim of this study was to determine the anthropometric characteristics and body composition of Nicaraguan athletes who participated in the 2024 Paris Olympic Games.

MATERIAL AND METHOD

Study Design. This study is an observational, descriptive, and cross-sectional case report. The case report format was selected due to the small sample size and highly specialized population (Nicaragua's Olympic delegation).

Participants. Five world-class Nicaraguan athletes (4 females, 1 male; age range: 18-26 years) agreed to participate and were selected through purposive sampling of Nicaragua's Olympic delegation. Athletes were in the final stage of their preparation to compete in the 2024 Paris Olympic Games across diverse disciplines: athletics (100m sprint), surfing (shortboard), swimming (400m butterfly), shooting (10m air rifle), and rowing (lightweight single sculls). All athletes provided written informed consent following protocols in accordance with the Declaration of Helsinki.

Data collection. Anthropometric and body composition parameters were calculated using standardized equations and protocols established in our previous works with world-class athletes (García-Carrillo *et al*., 2023; Herrera-Amante *et al*., 2025a,b). Complete anthropometric profiles of each athlete were assessed in June 2024 as part of their monitoring process for the Paris 2024 Olympic Games. Conducted following standardized ISAK protocol (Esparza-Ros *et al*., 2019), measurements were taken under standardized conditions (fasting, morning hours, 24h post-training) taken twice (thrice in case of discrepancies) by two level 2 ISAK-certified anthropometrists. Assessment included: 4 basic measurements (weight, height, sitting height, wingspan), 8 skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, front thigh, medial calf), 13 girths (arm, forearm, wrist, chest, waist, hip, thigh, calf, ankle), 9 lengths/heights (stature, sitting height, arm length, leg length, foot length, hand length, tibial height, upper arm length, lower arm length), and 9 bone diameters (biacromial, biiliocristal, biepicondylar humerus, biepicondylar femur, wrist breadth, ankle breadth, chest depth, foot breadth, head breadth).

Measurement Instruments. Anthropometric measurements were conducted using Holway brand instruments. Anthropometric tape: non-stretchable fiberglass with millimeter graduations. Stadiometer: accuracy of 0.1 cm. Scales: electronic to an accuracy of 100 grams. Professional skinfold caliper: resolution of 1.00 mm. Anthropometric box: 40 cm high, 50 cm wide and 30 cm deep. Large diameter gauge: accuracy of 0.1 cm.

Data processing. The anthropometric data were collected using the ISAKMetry software during measurements and subsequently analyzed through the program of the Ibero-American Institute of Sports and Human Movement Sciences, which generated outputs including body composition parameters, somatotype classifications, and derived anthropometric indices. Once the data was obtained, it was analyzed and represented in tables reflecting the measurements obtained of each athlete. Results were structured to highlight individual athlete profiles through presentation of absolute measurements and derived indices, consistent with case study reporting standards for small cohorts. No inferential statistics were applied given the descriptive nature of this case report.

Table I. General characteristics of athletes.

Variable	Olympic athletes				
Sex	F	F	M	F	F
Sport	ATHL	SURF	SWIM	SHOO	ROWI
Age (years)	25.0	18.0	19.0	21.0	26.0
Body weight (kg)	50.0	55.5	82.8	52.0	65.2
Height (cm)	162.0	160.9	183.0	160.0	165.0
Seated height (cm)	76.0	81.0	85.0	74.0	89.0
Wingspan (cm)	161.7	163.1	192.4	166.7	170.0

Note: F = female; M = male. ATHL = Athletics 100-meter sprint; SURF = Surfing (shortboard); SWIM = Swimming (400 meters butterfly); SHOO = 10m air rifle shooting; ROWI: lightweight single scull rowing.

RESULTS

Table I shows the general athlete's characteristics, including data on sex, age, sport discipline, and basic anthropometric variables such as body mass, height, sitting height, and wingspan. In terms of body mass, values ranged from 50.0 kg (athletics) to 82.8 kg (swimming), with the latter being the highest value among the male athletes. Among all athletes, the swimmer recorded the highest stature (183.0 cm), while the shooter showed the shortest (160.0 cm). Seated height ranged from 74.0 cm to 89.0 cm, with the rower having the longest torso. The wingspan ranged from 161.7 cm to 192.4 cm, with the latter also belonging to the swimmer, representing a relative wingspan index of over 100 %. This is a common characteristic among high-level swimmers, attributed to their mechanical advantage in aquatic propulsion. On the other hand, the sprinter exhibited a wingspan equivalent to her height (161.7 cm), indicating a more compact profile, which is associated with performance in short-duration, explosive events.

Table II presents the skinfold values, body components (fat, muscle, bone, residual, and skin), proportional indices, and somatotype of the five athletes. Skinfold measurements show differences depending on the sport: the track and field athlete (100 m) has the lowest values (∑8 skinfolds: 55.5 mm), while the surfer has the highest (97.0 mm), reflecting greater subcutaneous adipose tissue. In terms of body fat percentage, it ranges from 18.2 % (swimmers) to 30.4 % (surfers), with the lowest values observed in explosive or endurance disciplines. Relative muscle mass varies between 41.4 % and 53.7 %, being higher in the shooting athlete, which may be due to individual characteristics rather than sporting demands.

Muscular and structural indices such as the muscle/bone index (range: 3.2 to 4.8) and the fat/muscle index (range: 0.3 to 0.7) allow us to assess structural balance: The most favorable profile corresponded to the shooter and the sprinter, who have a higher muscle-to-bone mass ratio and a lower fat-to-muscle ratio. The relative wingspan index highlights the swimmer (105.1 %) and the rower (103.0 %), indicating a wingspan greater than their height, a biomechanical advantage in aquatic disciplines. Ultimately, the somatotype exhibits distinct profiles.

In athletics (100 m): mesomorphic ectomorph(1.8-3.0-3.7); Surfing: endomorphic mesomorph (3.0-3.6-2.3); Swimming: mesomorph endomorph (3.4-3.7-2.8); Shooting: ectomorphic mesomorph (1.5-4.9-3.2); Rowing: endomorphic mesomorph (3.4-5.5-1.5) (Table III).

Table II. Body composition and skinfold measurements by sport in Olympic athletes.

	Variables				
Sport	ATHL	SURF	SWIM	SHOO	ROWI
Triceps (mm)	7.0	15.0	5.0	10.0	13.0
Subscapular (mm)	6.0	6.0	6.5	10.0	10.0
Biceps (mm)	3.0	6.0	2.0	4.0	4.5
Iliac crest (mm)	8.0	10.0	9.0	14.0	12.0
Supraspinal (mm)	5.0	7.0	6.5	11.5	9.5
Abdominal (mm)	10.5	10.0	9.0	13.0	17.0
Front thigh (mm)	10.0	25.0	8.0	13.0	13.5
Medial calf (mm)	6.0	18.0	6.0	9.0	11.0
Body fat (kg)	12.0	17.3	15.5	14.9	17.2
Body fat (%)	24.8	30.4	18.2	27.5	25.4
Muscle mass (kg)	23.0	23.5	45.7	23.4	33.1
Muscle (%)	47.6	41.4	53.7	43.3	48.9
Bone (kg)	5.4	6.5	10.2	7.3	6.9
Bone (%)	11.1	11.5	12.0	13.4	10.2
Residual (kg)	4.8	6.2	9.5	5.3	6.9
Residual (%)	10.0	10.9	11.1	9.9	10.2
Skin (kg)	3.1	3.3	4.3	3.2	3.6
Skin(%)	6.5	5.7	5.0	5.8	5.3
Structured body mass	48.3	56.7	85.1	54.1	67.6
Dif. MCE-MCB (%)	3.3	2.2	2.8	4.0	3.6
Fat (kg)	12.4	16.9	15.0	14.3	16.6
Fat (%)	24.8	30.4	18.2	27.5	25.4
Muscle (kg)	23.8	23.0	44.4	22.5	31.9
	47.6	41.4	53.7	43.3	48.9
Bone (kg)	5.6	6.4	10.0	7.0	6.6
Bone (%)	11.1	11.5	12.0	13.4	10.2
Residual (kg)	5.0	6.1	9.2	5.1	6.7
Residual (%)	10.0	10.9	11.1	9.9	10.2
Skin (kg)	3.2	3.2	4.2	3.0	3.4
Skin (%)	6.5	5.7	5.0	5.8	5.3
Body mass Restructured	50.0	55.5	82.8	52.0	65.2
Diff. MCRE-MCRB (%)	0.0	0.0	0.0	0.0	0.0
Fat MassZ					
Muscle Mass Z-score [5C]	0.1	-0.1	4.1	-0.2	1.7
Bone Mass Z-score [5C]	-0.6	0.0	2.8	0.5	0.2
Residual Mass Z-score [5C]	-0.7	0.2	3.0	-0.6	0.7

Note: 5C = 5-component body composition model.

In relation to wingspan, it can be observed that the short-distance rower (170 cm) and the swimmer (192.4 cm) have the highest values, which is consistent with the mechanical demands of these disciplines, where a greater wingspan can translate into greater propulsive efficiency (Oliveira *et al*., 2021). Podstawski *et al*. (2022), showed that elite rowers in the 19-22 age group had a wingspan of 176.9 cm, which is greater than that found in our athlete.

In contrast, the 100-metre sprinter, with a wingspan equivalent to her height (wingspan index 99.8), reflects a more balanced and compact somatotype, common in sprinters where explosive force production takes priority over body lever length (Jakovljevic *et al*., 2022). Elite athletes are expected to have low body fat and higher muscle tissue values, which enable optimal performance (Thomas et al., 2016; Mathisen et al., 2023). Furthermore, as previously reported, excess body fat can reduce movement speed due to the additional body mass that the muscular system needs to carry (Thomas *et al*., 2016; Herrera-Amante *et al*., 2025a,b). The 100-metre sprinter has the lowest fat percentage (12 %), which is consistent with the high-power demands of speed events (Abe *et al*., 2019; Miller *et al*., 2024).

In terms of muscle mass percentage, the shooting athlete stands out (53.7 %), which is striking given the low physical demands of her sport. This could be attributed to greater overall muscle mass that is not necessarily functional for her sport, or to individual characteristics that cannot be trained. Several studies have documented that sports such as shooting tend to have lower muscle mass indices compared to strength or endurance sports, reflecting specific adaptations to the demands of the sport, as well as genetic or individual factors beyond specific training (Walker *et al*., 2023; Canda, 2024). It has been demonstrated that between 30 % and 50 % of the variation in muscle mass can be attributed to genetic factors (Arden & Spector, 1997).

Furthermore, it has been demonstrated that diverse disciplines present different body compositions, suggesting that not all muscle mass contributes directly to performance if it is not aligned with local biomechanical or strength demands (González-Cano *et al*., 2024). Swimmers, on the other hand, have 43.3 %, which is to be expected

Figure 1 shows the somatopoints in the somatocarts of the Nicaraguan Olympic athletes of Paris 2024.

DISCUSSION

This case study allowed us to characterize the anthropometry and body composition of five Nicaraguan athletes participating in the 2024 Paris Olympic Games. The results reveal differences between the various disciplines, considering four female athletes and one male athlete, which aligns with the literature, which highlights morphological specificity as a key determinant of athletic performance (Sekulic *et al*., 2021; Martínez-Miralles *et al*., 2025).

Table III. Anthropometric indices and somatotype profiles in Olympic athletes.

	Indexes				
Sport	ATHL	SURF	SWIM	SHOO	ROWI
BMI	19.1	21.4	24.7	20.3	23.9
Waist-to-Height	0.4	0.4	0.5	0.4	0.5
Height-to-Biacromial	4.5	4.4	4.1	4.2	4.6
Height-to-Bii					
Biacromial-to-Biiliocristal	1.5	1.4	1.5	1.3	1.3
∑6 Skinfolds	44.5	81.0	41.0	66.5	74.0
∑8 Skinfolds (ISAK)	55.5	97.0	52.0	84.5	90.5
Muscle-to-Bone Mass	4.3	3.6	4.5	3.2	4.8
Adipose-to-Muscle Mass	0.5	0.7	0.3	0.6	0.5
Crural-Troch-Tib/A.Tib/Lat.	1.0	1.0	1.1	1.0	1.0
Cormic Index	46.9	50.3	46.4	46.3	53.9
Relative Span Index	99.8	101.4	105.1	104.2	103.0
Thoracic Index	61.3	64.2	61.7	59.5	62.8
Brachial Ratio	77.2	79.3	78.8	82.0	84.2
	Somatotype				
Endomorphy	1.8	3.0	1.5	3.4	3.4
Mesomorphy	3.0	3.6	4.9	3.7	5.5
Ectomorphy	3.7	2.3	2.2	2.8	1.5
X	1.9	-0.7	0.7	-0.6	-2.0
Y	0.5	1.9	6.0	1.2	6.0

Note: ∑6 Skinfolds = (triceps, subscapular, supraspinal, abdominal, front thigh, and medial calf); 5C = 5-component body composition model; Crural-Troch-Tib/A.TibLat = lower leg proportion ratio (tibiale-trochanterion : tibiale-sphyrion tibiale).

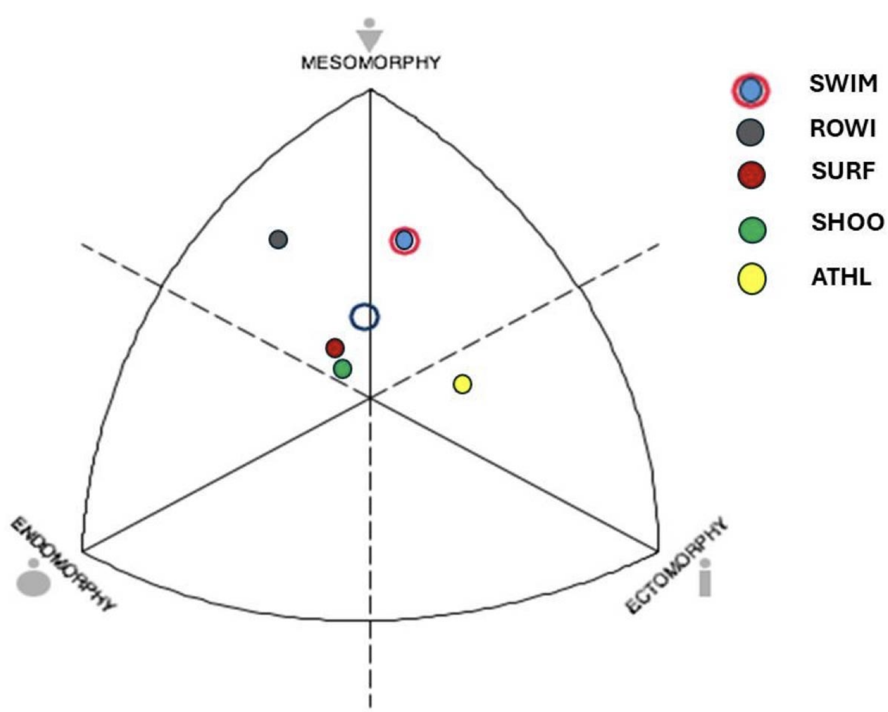

Fig. 1. Somatotype of Nicaraguan Olympic athletes.

considering the influence of resistance training in water, which prioritizes functional but not necessarily hypertrophied muscles (Zampagni *et al.*, 2008). Studies have shown that lean mass, especially in the trunk and arms, correlates strongly (r = 0.44–0.64) with pulling power in the 100-metre front crawl test (Strzala *et al.*, 2020).

The muscle-to-bone and adipose-to-muscle indices are complementary indicators for assessing the structural efficiency of athletes (Domaradzki & Koz´lenia, 2022). A high muscle-to-bone index suggests greater muscle development in relation to the skeleton. In contrast, a low adipose-to-muscle index indicates a predominance of fat tissue over muscle tissue (Canda, 2024). In this study, the best profiles in these indices were observed in rower (muscle-to-bone ratio: 4.8; fat-to-muscle ratio: 0.5), swimmer (muscle-to-bone ratio: 4.5; fat-to-muscle ratio: 0.3) and 100-meter sprinter (muscle-to-bone ratio: 4.3; fat-to-muscle ratio: 0.5), which confirms their good body proportions. In contrast, the shooter showed a lower muscle/bone index (3.2), which could indicate lower relative muscle density or a specific adaptation to his discipline of low musculoskeletal impact.

Finally, somatotype enables a comprehensive classification of morphology. Athletes competing in the 100 meters (1.8-3.0-3.7) and shooting (1.5-4.9-3.2) have marked ectomorphic and mesomorphic components, in line with their respective requirements. The short-distance rower (3.4-5.5-1.5), with a mesoendomorphic profile, reflects the high demands of strength and endurance in their discipline. The swimmer (3.4-3.7-2.8) has a more mixed profile, typical of middle-distance swimmers, combining power, endurance and postural control (Carter & Heath, 1990; Baranauskas *et al.*, 2024).

CONCLUSION

Results from this study showed examples of biomechanical advantages suited to water propulsion and endurance-strength performance including the swimmer's noticeable wingspan (105.1 % relative to height) and the rower's lengthened torso. With low fat percentages (12–30.4 %) and high muscle-to-bone ratios (up to 4.8), athletes demonstrated optimal body composition profiles, particularly in sports requiring precision (shooting) and explosiveness (sprinting). In accordance with the physiological requirements of each discipline, somatotypes varied systematically from ecto-mesomorphic (sprinter) to meso-endomorphic (rower). These results highlight the importance of anthropometric profiling in Nicaragua's top sports programs for identifying talent and tailoring training. This study emphasizes the necessity for longitudinal studies to track athlete development and lays the groundwork for future research on under-represented Olympic delegations. The findings give sports scientists and coaches information to help with athlete training and selection, while advocating for expanded investigations into Central American athletic populations to bridge regional research gaps.

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RESUMEN: Las características antropométricas y la composición corporal influyen significativamente en el rendimiento deportivo de élite. Sin embargo, los datos sobre atletas olímpicos siguen siendo limitados. Este estudio transversal tuvo como objetivo determinar las características antropométricas y composición corporal de deportistas nicaragüenses que participaron en los Juegos Olímpicos de París 2024. Cuatro atletas femeninas (velocista de 100 metros, surf de shortboard, tiro y remo corto) y un atleta masculino (natación, 400 metros mariposa) participaron en este estudio de caso. Las mediciones incluyeron 8 pliegues cutáneos, 13 perímetros, 9 longitudes/alturas y 9 diámetros óseos, evaluados con instrumentos calibrados Holway siguiendo protocolos ISAK. Los datos se procesaron mediante el software ISAKMetry para análisis de composición corporal y somatotipo. El nadador presentó la mayor masa corporal (82.8 kg), estatura (183 cm) y envergadura (192.4 cm; índice de envergadura relativa: 105.1 %), mientras que la tiradora fue la más baja (160 cm). El porcentaje de grasa corporal varió del 18.2 % (nadador) al 30.4 % (surfista), con la velocista mostrando el valor más bajo entre las mujeres (24.8 %). El porcentaje de masa muscular osciló entre 41.4 % (surfista) y 53.7 % (tiradora). Los índices revelaron proporciones óptimas músculo-hueso (4.5) y grasa-músculo (0.3) en la tiradora. Los somatotipos reflejaron adaptaciones específicas por disciplina, incluyendo perfiles ecto-mesomórfico (velocista), meso-endomórfico (remo) y meso-ectomórfico (natación). Estos hallazgos destacan patrones morfológicos distintivos asociados a las demandas específicas de cada deporte, proporcionando datos de referencia valiosos para la identificación de talentos y la optimización del entrenamiento en atletas nicaragüenses de élite.

PALABRAS CLAVE: Antropometría; Composición Corporal; Rendimiento Deportivo; Somatotipos; Deportes; Tejido Adiposo.

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