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Anthropometric and Physical Fitness Characteristics of Chilean Elite Junior Surfers

Características Antropométricas y de Aptitud Física de Surfistas Juveniles de Élite Chilenos

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SUMMARY: Anthropometric and physical fitness characteristics significantly influence surfing performance. Despite this importance, the anthropometric profiles of elite junior surfers remain poorly characterized in the scientific literature. The objective of this study was to analyze the anthropometric characteristics and physical fitness of elite junior surfers by sex. Eight surfers from Promesas Chile, the national high-performance government program (5 men: 18.8 ± 3.0 years, and 3 women: 20.2 ± 4.2 years) participated in the study. Anthropometric characteristics, somatotype, muscle strength, lower-body power, functional movement, and stability were assessed. The results showed differences in muscle mass (p=0.036), with men having higher level of muscle mass (35.2 vs. 25.6 kg). Men had a higher CMJ jump in the right leg (p=0.036), and in handgrip of the right and left hands (p=0.036), the IMPT was higher in men compared to women. The somatotype of men was Ectomorph-Mesomorph (2.1-5.0-2.7) and that of women was Mesomorph-Endomorph (4.2-4.2-1.8). Men also presented higher levels of isometric shoulder strength than women. Men also presented higher levels of isometric strength of the posterior chain at 30°. It is concluded that men present different anthropometric characteristics than women, with men presenting greater ectomorphy and less endomorphy. In addition, men have higher levels of handgrip strength, mobility and stability. The results of the present study allow for the orientation of differentiated training strategies by sex to optimize anthropometric characteristics and physical performance in athletes.

KEY WORDS: Surfing; Exercise; Performance; Body composition; Anthropometry.

INTRODUCTION

In recent years, surfing has seen a rise in number of practitioners and had a significant evolution in performance, particularly in the last two decades with the introduction of aerial maneuvers in competitions. In addition, surfing became an Olympic sport in 2021, demanding high-quality performance from surfers, elevating the risk of injury due to complex maneuvers and competitive score requirements (Seixas *et al*., 2024). Surfing is composed of different moments demanding specific skills and abilities for each situation, so properly developing these attributes will contribute to better surfing performance, spending about 51% of the time paddling, 42% in a stationary position (i.e., waiting). In comparison, the current point-scoring activity of surfing waves only represents 4% of their activity profile (Méndez & Villanueva, 2006). Although the practice of surfing has increased in recent years, there are still only few studies analyzing anthropometric characteristics and physical fitness variables according to sex in this sport, especially in

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Latin American athletes. According to a recent consensus statement of the American College of Sports Medicine (Hunter *et al*., 2023), men outperform women in sports and athletic activities that require aerobic endurance, muscular strength, power, and speed. Biological differences between men and women result in a sex difference of 10 % and 30 % in athletic performance. However, the magnitude depends on the demands of the event/sport and which biological systems are most involved. In surfing, the accumulated evidence shows that the performance analysis in this sport is limited (Farley *et al*., 2017). Consequently, there is a clear need to develop studies that expand our understanding of high-performance surfing.

Surfing is an individual sport in an aquatic environment where athletes must ride waves with boards, trying to make complex maneuvers, so it requires significant development of physical condition (Barlow *et al*., 2014). It is practiced in a dynamic environment, with challenging situations that force surfers to adapt to variable ocean conditions while maintaining a high level of performance. Surfing competitions last from 20 to 40 minutes, depending on the format of the competition, and the surfers' activity is characterized by repeated bouts where the development of balance and strength is required (Fernandez-Gamboa *et al*., 2017). This sport is intermittent and is characterized by a significant variability and random distribution of each physical parameter, which requires great dexterity (Mendez-Villanueva *et al*., 2006). Surfers must have well-developed cardiorespiratory fitness, muscular endurance and anaerobic power, especially in the upper torso (Loveless & Minahan, 2010), and lower body strength and power capabilities appear to play an important role in surfing performance (Tran *et al*., 2015). Considering the various factors that influence performance, surf athletes need an equally diverse set of skills and abilities to succeed in competition (Klingner *et al*., 2022). Furthermore, it is important to consider that lower limb injuries are the most common injuries in surfing competitors (Dowse *et al*., 2021), and appear to be primarily related to landing tasks, highlighting the need for a multifactorial approach to assessing landing skills (e.g., ankle range of motion, isometric midthigh pull, lower body strength, time to stabilization during a drop-and-stick (DS) landing, relative peak force during a DS landing, relative peak force during a DS landing), ankle dorsiflexion range of motion, isometric midthigh pull, lower body strength, time to stabilization during a drop-and-stick (DS) landing, relative peak force during a DS landing), recognizing that multiple factors contribute to both success and safety in these tasks (Lundgren *et al*., 2015).

Moreover, these qualities must be developed based on an anthropometric profile that allows optimal maneuvering in the water (Silva & Clemente, 2019), so analyzing the interface between structure and function takes on fundamental importance. In this sense, body composition is recognized as a determinant of health and athletic performance (Espada *et al*., 2023). Its assessment is essential to identify nutritional status and the effect of nutritional interventions (Campa *et al*., 2021). This is why the analysis of body composition has become a fundamental and essential part in its evaluation and in the optimization of sports performance (Toselli, 2021). In surfing, anthropometric assessment is of great importance as it allows monitoring of performance and the effects of training. As this is a gravitational sport, body composition directly affects performance in the water with a high effect (Ackland *et al*., 2012). In this sport, it is relevant to integrate good nutritional practices as these can affect athletic performance and impact the anthropometric characteristics of athletes (Felder *et al*., 1998). Moreover, somatotype determines athletic performance, influencing strength, endurance and sport-specific skills depending on the discipline (Jakovljevic´ *et al*., 2022).

In general, male athletes tend to have a more mesomorphic somatotype, characterized by a muscular and robust build, while female athletes often exhibit a higher endomorphic component, indicating a more significant proportion of fat and softer body composition. (Slankamenac *et al*., 2022). In summary, comprehensive assessment of anthropometric characteristics, physical fitness, mobility, and stability is essential to designing effective training programs that optimize performance and reduce the risk of injury in surfers. Considering this background, this study aims to analyze the anthropometric and physical fitness characteristics of elite junior surfers in Chile according to sex.

PARTICIPANTS AND METHOD

Participants. Eight elite-level Chilean surfers participated in the study (5 men: 18.8 ± 3.0 years, 3 women: 20.2 ± 4.2 years), with a body mass index of 22.9 ± 1.6 (23.0 ± 2.1 in men and 22.6 ± 0.5 in women). The descriptive characteristics of the participants are presented in Table I.

Data collection. Anthropometric characteristics, muscle strength, lower-body power, and functional movement and stability were assessed through a standardized test battery conducted over three sessions. All assessments were performed following written informed consent from participants, based on the recommendations of the Declaration of Helsinki for studies involving human subjects (World Medical Association, 2013). The present study was approved by the Biosecurity, Research and Ethics Committees of the Division of Health Sciences of the University of Guadalajara, University Center of Tonalá (code: CEI-062020-01).Before testing, participants received detailed verbal and written explanations of the testing

Table I. Descriptive characteristics of elite junior surfers.

Characteristic	All (N=8)	Male (n=5)	Female (n=3)	*p*	g
Age (years)	19.4 ± 3.0	18.8 ± 2.5	20.2 ± 4.2	0.786	-0.44
Body mass (kg)	65.1 ± 6.8	69.4 ± 3.6	57.7 ± 3.0	0.003*	3.43
Standing height (cm)	168.6 ± 9.0	174.0 ± 5.4	159.7 ± 5.8	0.012*	2.58
Sitting height (cm)	88.4 ± 4.9	91.0 ± 3.3	84.0 ± 4.0	0.051	1.97
BMI (kg/m^2)	22.9 ± 1.6	23.0 ± 2.1	22.6 ± 0.5	1.000	0.20
Legs length (cm)	96.4 ± 23.0	94.2 ± 30.1	100.0 ± 3.5	0.549	-0.24

Abbreviations: BMI = body mass index. Note: between-sex difference: * $p < 0.05$

procedures, potential risks, and their rights as research subjects. Two ISAK-certified anthropometrists and 3 strength-conditioning specialists supervised testing to ensure protocol adherence.

Anthropometric measurements. Height, body mass, eight skinfolds (biceps, triceps, subscapular, suprailiac, abdominal, thigh, chest, and calf), breadths (humerus and femur) and girths (arm, forearm, chest, medial thigh and medial calf) were assessed. Breadth measurements included biacromial, chest transverse, chest anterior-posterior, biiliocristal, humerus, and femur diameters, taken using a skinfold calliper (Harpenden, HSB-BI, HaB Direct, UK) with a precision of 0.2 mm. Girth measurements assessed head, relaxed arm, flexed arm, forearm, chest, waist, hip, thigh (gluteal and mid-thigh), and calf circumferences, recorded with a flexible steel tape with a 1 mm accuracy following ISAK standards.

Muscle strength and lower-body power. The isometric push-up test was performed by maintaining the push-up position, generating maximal force without movement, and measuring the peak force exerted on a force platform (PASCO Scientific, California, USA) placed under each hand. The isometric mid-thigh pull (IMTP) was conducted in a standardized pulling posture, with the hips and knees flexed at 20° and 40°, respectively. Participants grasped a fixed bar positioned above a force platform. Following two warm-up trials, they executed a 5-second maximal voluntary contraction. Peak force (N) from each leg was recorded using a force platform (PASCO Scientific, California, USA), and the highest value was retained for analysis. The 90° back squat one-repetition maximum (1RM) test was performed after a standardized 5-minute warm-up. Participants lifted a barbell with progressively increasing loads until achieving their 1RM (the heaviest load lifted with proper technique). Three spotters were present for safety, and rest intervals of 3–5 minutes were provided between attempts. For the leg extension test, participants were seated with the knee flexed at 60° and performed maximal voluntary contractions against a fixed pad connected to a load cell (Chronojump Boscosystems, Barcelona, Spain) for 3–5 seconds. Lower-limb power was assessed using the Bosco jump test, which included the following measurements: squat jump (SJ) height, bilateral and unilateral countermovement jump (CMJ) height, Abalakov jump (ABK) height, and in the drop jump (DJ), flight time, contact time, and jump height. Three trials were performed for each jump, with the best attempt used for analysis. Measurements were obtained using a jump mat system (Chronojump Boscosystems, Barcelona, Spain). Maximal voluntary handgrip strength in both hands was evaluated using a calibrated Jamar dynamometer (Lafayette Instrument, Lafayette, IN, USA). Three trials were performed according to previously described procedures (Garcia-Carrillo et al., 2023), and the best attempt was used for analysis.

Functional movement and stability. Functional movement assessment included overhead squat and shoulder mobility tests following standardized procedures. For the overhead squat, participants held a wooden dowel overhead while performing maximal-depth squats. Evaluation criteria included dowel alignment, torso and leg mechanics, and joint stability, scored on a 0–3 scale. Shoulder mobility was assessed bilaterally by measuring the distance between fists during a combined flexion–extension motion, normalized to hand length. All tests were video recorded and independently scored by two experienced evaluators. Three practice attempts were permitted before formal testing. A score of "0" was assigned if pain occurred during movement. The inline lunge test was used to assess dynamic stability and functional lower-limb mobility. Participants positioned their feet in a heel-to-toe alignment along a straight line, with hands on hips. They descended into a lunge until the rear knee lightly touched the ground, maintaining spinal alignment and heel contact of the front foot. Three trials per side were recorded, with the best performance retained for analysis. In the Y-Balance Test (YBT), participants performed maximal reaches in three directions (anterior, posteromedial, and posterolateral) while balancing on one leg. During each attempt, they pushed a movable indicator along a measuring scale with the non-supporting foot, holding the final position for one second to ensure stability. Three attempts per direction and limb were recorded; the maximum reach distance (cm), normalized to leg length, was averaged for analysis. For the sit-and-reach test, participants sat on the floor with legs fully extended, feet shoulder-width apart against a measurement box, and knees pressed to the floor. They performed a maximal forward trunk flexion with both hands, and the greatest distance reached was recorded. Three trials were allowed with 30-second rest intervals; the best score was used for analysis. The Alpha Shoulder Harness (ASH) test was conducted in three positions: I (internal rotation), Y (scapular elevation), and T (horizontal abduction). In each position, force (N) was measured using a force platform (PASCO Scientific, California, USA). Participants performed movements against standardized resistance while wearing the harness, and range of motion (°) and produced force (N) were recorded for each position. The McCall test was performed at knee flexion angles of 30° and 90° for both lower limbs. Participants were seated in a dynamometer chair with hips fixed at 110° of flexion and the test limb secured to a force transducer. For each condition (30°/90° right, 30°/90° left), maximal voluntary contractions were held for 5 seconds. In each position, force (N) was recorded using a force platform (PASCO Scientific, California, USA). Three trials per angle were performed, with 2-minute rest intervals between tests.

Statistical analysis. The Shapiro-Wilk test indicated that the data met the assumption of normality. Therefore, variables were presented as mean ± standard deviation. Given the small sample sizes, the non-parametric Mann-Whitney U test was employed to analyze between-sex comparisons (Hollander *et al*., 2014). Hedges' g effect sizes were calculated to assess the magnitude of differences, with the following interpretations: < 0.20 considered trivial; 0.20-0.59 as small; 0.60-1.19 as moderate; 1.20-1.99 as large; and ≥ 2.00 as very large (Hopkins *et al*., 2009). Data analyses were performed using IBM SPSS Statistics, version 23.0 (IBM Corp., Armonk, N.Y., USA). Statistical significance was defined as p<0.05.

RESULTS

Table II shows the participants anthropometric variables. Differences were observed between men and women in the biacromial diameters (men 40.8 ± 1.4; women: 36.4 ± 2.0; p=0.009), humeral (men 7.0 ± 0.7; women: 5.9 ± 0.6; p=0.016) and femoral (men 9.8 ± 0.5; women: 8.6 ± 0.5; p=0.017), head circumferences (men 55.6 ± 1.2; women: 53.1 ± 0.2; p=0.016), flexed arm under tension (men 33.5 ±

Table II. Anthropometric characteristics of elite junior surfers.

Variables	All (N=8)	Male (n=5)	Female (n=3)	*p*	g
		Breadths			
Biacromial	39.1 ± 2.7	40.8 ± 1.4	36.4 ± 2.0	0.009*	2.74
Chest transverse	26.5 ± 2.5	27.9 ± 1.0	24.1 ± 2.4	0.071	2.38
Chest anterior posterior	17.2 ± 1.9	17.9 ± 2.1	15.9 ± 0.2	0.230	1.22
Biiliocristal	26.8 ± 0.8	26.9 ± 0.9	26.7 ± 0.9	0.881	0.19
Humerus	6.6 ± 0.7	7.0 ± 0.3	5.9 ± 0.6	0.016*	2.44
Femur	9.3 ± 0.8	9.8 ± 0.5	8.6 ± 0.5	0.017*	2.40
		Girths			
Head	54.6 ± 1.6	55.6 ± 1.2	53.1 ± 0.2	0.016*	2.42
Relaxed arm	30.7 ± 1.5	31.1 ± 1.8	30.1 ± 0.4	0.393	0.71
Flexed and contracted arm	32.3 ± 2.2	33.5 ± 1.8	30.2 ± 0.8	0.023*	2.21
Forearm	26.7 ± 1.8	27.9 ± 0.7	24.6 ± 0.6	0.001*	5.20
Chest	93.7 ± 5.8	97.3 ± 3.5	87.6 ± 2.6	0.006*	3.04
Waist	74.4 ± 4.4	76.9 ± 2.7	70.2 ± 3.4	0.020*	2.31
Hip	95.7 ± 2.4	96.8 ± 1.7	93.9 ± 2.5	0.143	1.43
Thigh (1cm gluteal)	56.1 ± 2.3	56.5 ± 2.5	55.4 ± 2.2	0.653	0.46
Mid-thigh	51.3 ± 1.8	51.7 ± 1.7	50.6 ± 2.0	0.786	0.61
Calf	34.2 ± 1.0	34.8 ± 0.8	33.4 ± 0.6	0.051	1.91
		Skinfolds			
Biceps	5.2 ± 2.8	4.1 ± 1.1	7.0 ± 4.0	0.451	-1.16
Triceps	11.3 ± 5.8	8.4 ± 3.0	16.2 ± 6.8	0.072	-1.70
Subscapular	9.6 ± 3.2	8.0 ± 1.3	12.3 ± 3.8	0.230	-1.79
Iliac crest	15.9 ± 5.1	13.0 ± 3.2	20.7 ± 4.0	0.024*	-2.20
Supraspinal	8.0 ± 2.7	6.2 ± 1.2	11.0 ± 1.0	0.001*	-4.35
Abdominal	12.6 ± 4.2	9.9 ± 1.8	17.0 ± 2.7	0.003*	-3.40
Thigh	13.8 ± 6.9	10.3 ± 2.5	19.7 ± 8.5	0.174	-1.76
Calf	8.6 ± 3.7	6.6 ± 2.0	12.0 ± 3.6	0.143	-2.02

Note: between-sex difference: * p<0.05.

1.8; women: 30.2 ± 0.8; p=0.023), forearm (men 27.9 ± 0.7; women: 24.6 ± 0.6; p=0.001), chest (men 97.3 ± 3.5; women: 87.6 ± 2.6; p=0.001) and waist (men 76.9 ± 2.7; women: 70.2 ± 3.4; p=0.020) and iliac crest skinfolds (men 13.0 ± 3.2; women: 20.7 ± 4.0; p=0.024), supraspinal (men 6.2 ± 1.2; women: 11.0 ± 1.0; p=0.001) and abdominal (men 9.9 ± 1.8; women: 17.0 ± 2.7; p=0.003). No differences were found in the other variables.

Table III. Body composition and somatotype characteristics of elite junior surfers.

Variable	All (N=8)	Male (n=5)	Female (n=3)	*p*	g
Body composition					
Muscle mass (kg)	31.6 ± 5.7	35.2 ± 2.9	25.6 ± 3.3	0.005*	3.16
Muscle Mass (%)	48.3 ± 4.3	50.6 ± 3.2	44.5 ± 3.1	0.071	1.93
Adipose mass (kg)	15.9 ± 2.4	15.0 ± 2.1	17.5 ± 2.3	0.250	-1.15
Adipose mass (%)	24.9 ± 6.0	21.6 ± 3.1	30.8 ± 5.5	0.071	-2.22
Fat mass (kg)	10.3 ± 2.7	9.0 ± 1.8	12.4 ± 2.7	0.250	-1.62
Fat mass (%)	16.3 ± 5.9	12.9 ± 2.7	21.8 ± 5.7	0.071	-2.24
Residual mass (kg)	6.7 ± 1.5	7.6 ± 0.7	5.2 ± 1.0	0.008*	2.86
Residual mass (%)	10.3 ± 1.3	11.0 ± 0.7	9.1 ± 1.2	0.143	2.06
Skin mass (kg)	3.6 ± 0.4	3.8 ± 0.3	3.1 ± 0.2	0.008*	2.86
	5.5 ± 0.2	5.5 ± 0.7	5.4 ± 0.1	0.760	0.25
Bone mass (kg)	7.2 ± 1.2	7.9 ± 0.9	6.0 ± 1.0	0.018*	2.37
Bone mass (%)	11.1 ± 1.1	11.4 ± 0.5	10.5 ± 1.2	0.393	0.97
Somatotype and index					
Endomorph	2.9 ± 1.3	2.1 ± 0.6	4.2 ± 1.2	0.013*	-2.55
Mesomorph	4.7 ± 0.6	5.0 ± 0.9	4.2 ± 0.4	0.134	1.42
Ectomorph	2.4 ± 0.9	2.7 ± 0.5	1.8 ± 0.5	0.230	1.10
BMIbone	4.4 ± 0.4	4.5 ± 0.2	4.3 ± 0.3	0.571	0.40
WHR	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.1	0.143	1.18
WHtR	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.786	0.03
Sum of skinfolds					
∑6 skinfolds (mm)	63.9 ± 25.2	49.4 ± 9.0	88.2 ± 25.4	0.071	-2.36
∑ 8 skinfolds (mm)	85.0 ± 32.4	66.5 ± 12.1	115.8 ± 33.0	0.071	-2.30

Abbreviations: BMI = body mass index; BMIbone = bone mass index; WHR = waist-to-hip ratio; WHtR = waist-to-height ratio. Note: between-sex difference: * $p<0.05$.

Table IV. Muscle strength and lower-body power of elite junior surfers.

Variable	All (N=8)	Male (n=5)	Female (n=3)	*p*	g
Right isometric push-up (N)	400.1 ± 74.4	421.1 ± 89.6	365.0 ± 19.5	0.786	0.76
Left isometric push-up (N)	367.8 ± 85.8	383.9 ± 108.9	341.1 ± 18.4	0.786	0.48
IMTP max force right (N)	1028.6 ± 250.4	1175.0 ± 168.3	784.7 ± 141.4	0.016*	2.44
IMTP max force left (N)	956.4 ± 140.3	1047.0 ± 63.7	805.4 ± 77.4	0.003*	3.52
1RM 90° squat (kg)	56.9 ± 13.0	55.1 ± 16.4	60.0 ± 5.3	0.881	-0.36
Right leg extension (N)	416.0 ± 84.6	465.9 ± 63.7	332.9 ± 18.1	0.014*	2.51
Left leg extension (N)	428.4 ± 82.0	472.8 ± 68.1	354.5 ± 33.4	0.033*	2.01
Lower-body power					
SJ (cm)	28.9 ± 5.2	30.6 ± 5.5	26.1 ± 3.8	0.393	0.90
CMJ (cm)	33.0 ± 4.7	34.5 ± 4.8	30.4 ± 3.7	0.250	0.92
CMJ right (cm)	14.2 ± 2.8	16.2 ± 0.8	10.9 ± 0.2	<0.001**	7.63
CMJ left (cm)	14.8 ± 3.7	15.3 ± 4.5	13.9 ± 2.5	1.000	0.35
ABK (cm)	38.7 ± 7.4	41.3 ± 7.1	34.6 ± 6.8	0.393	0.95
DJ height (cm)	29.7 ± 4.7	29.7 ± 5.9	29.7 ± 2.3	1.000	0.00
DJ contact time (ms)	322.8 ± 195.0	377.0 ± 235.2	232.3 ± 53.5	0.393	0.74
DJ flight time (ms)	482.3 ± 48.4	490.6 ± 49.6	468.3 ± 53.1	0.571	0.44
Handgrip strength					
HGS right (kg)	42.2 ± 10.4	47.7 ± 8.9	33.0 ± 3.9	0.038*	1.93
HGS left (kg)	42.5 ± 9.8	48.7 ± 5.7	32.1 ± 3.9	0.005*	3.20

Abbreviations: ABK = Abalakov jump; CMJ = countermovement jump; DJ = drop jump; HGS = handgrip strength; SJ = squat jump. Note: between-sex difference: * $p<0.05$.

Body composition and somatotype are shown in Table III. Body composition analysis revealed males had greater muscle mass (35.2 vs 25.6 kg), residual mass (7.6 vs 5.2 kg), bone mass (7.9 vs 6.0 kg), head circumference (55.6 vs 53.1 cm), lower level of endomorphy (2.6 vs 4.2), and higher fat-free mass index (3.1 vs 2.6) (all $p<0.05$). Other variables showed no sex differences.

Physical fitness outcomes (Table IV) showed sex differences in right-leg CMJ (16.2 ± 0.8 cm vs 10.9 ± 0.2 cm; $p<0.001$) and bilateral grip strength (right: $p=0.038$; left: $p=0.005$), with males outperforming females.

Table V. Functional movement and stability of elite junior surfers.

Variable	All (N=8)	Male (n=5)	Female (n=3)	*p*	g
FMS Squat	2.5 ± 0.5	2.4 ± 0.6	2.7 ± 0.6	0.608	-0.48
FMS right shoulder mobility	2.6 ± 0.5	2.4 ± 0.6	3.0 ± 0.0	0.158	-1.34
FMS left shoulder mobility	2.9 ± 0.4	2.8 ± 0.6	3.0 ± 0.0	0.606	-0.55
Right line lunge	2.8 ± 0.5	2.6 ± 0.6	3.0 ± 0.0	0.324	-0.89
Left line lunge	2.5 ± 0.5	2.4 ± 0.6	2.7 ± 0.6	0.608	-0.48
YBT right anterior	67.6 ± 9.9	71.4 ± 10.7	61.3 ± 4.7	0.294	1.10
YBT right posterolateral	115.9 ± 18.1	125.8 ± 14.7	99.3 ± 7.1	0.071	2.08
YBT right posteromedial	104.5 ± 14.4	110.0 ± 14.3	95.3 ± 11.0	0.393	1.11
YBT left anterior	64.9 ± 11.1	66.0 ± 14.1	95.3 ± 5.0	0.881	0.25
YBT left posterolateral	109.8 ± 14.0	113.4 ± 12.1	63.0 ± 17.5	0.453	0.69
YBT left posteromedial	104.4 ± 17.2	113.2 ± 14.3	103.7 ± 10.0	0.097	1.80
SRT (cm)	37.2 ± 7.7	35.4 ± 9.6	40.2 ± 0.6	1.000	-0.60
ASH right I	145.2 ± 31.8	167.5 ± 9.6	89.7 ± 6.9	<0.001*	6.76
ASH right Y	113.0 ± 23.8	128.3 ± 11.8	87.5 ± 12.2	0.003*	3.41
ASH right T	91.8 ± 19.3	103.7 ± 6.4	72.1 ± 16.6	0.007*	2.90
ASH left I	137.3 ± 30.9	156.6 ± 18.9	105.1 ± 12.1	0.006*	3.05
ASH left Y	102.6 ± 29.6	123.7 ± 6.7	67.5 ± 4.6	<0.001*	9.28
ASH left T	90.8 ± 22.9	105.2 ± 12.9	66.6 ± 10.0	0.005*	3.22
McCall test right 30°	277.7 ± 57.7	310.4 ± 46.4	223.2 ± 14.7	0.022*	2.25
McCall test right 90°	275.3 ± 49.5	300.9 ± 44.1	232.6 ± 18.3	0.143	1.82
McCall test left 30°	256.1 ± 43.1	282.4 ± 30.3	212.3 ± 7.3	0.009*	2.80
McCall test left 90°	258.7 ± 43.8	278.5 ± 43.8	225.6 ± 16.3	0.143	1.43

Abbreviations: ASH = athletic shoulder test; FMS = functional movement screen test; SRT = sit and reach test; YBT = Y-balance test.
Note: between-sex difference: * $p<0.05$.

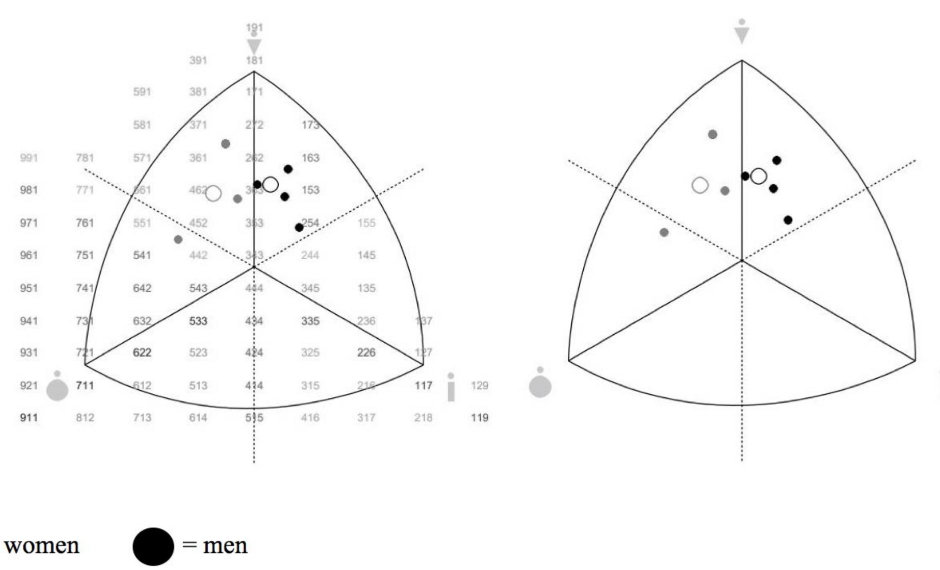

Fig. 1. Somatotype by sex.

Table V presents the functional movement and stability variables. Differences between male and female were observed in the IMTP max force right (men 1047.0 ± 63.7 N; women: 805.4 ± 77.4 N; p=0.003), and left (men 47.7 ± 8.9kg; women: 32.1 ± 3.9kg; p=0.005). Similarly, there were differences in the ASH and McCall 30° tests, with men outperforming women (p<0.005). No differences were found on the remaining variables.

Figure 1 shows the somatotype of participants. Male athletes presented an ectomorphic-mesomorphic profile (2.1-5.0-2.7), while female athletes showed a mesomorphic-endomorphic predominance (4.2-4.2-1.8).

DISCUSSION

The present study aimed to analyze the anthropometric and physical fitness characteristics of elite junior surfers in Chile according to sex. Among the most relevant results, men presented greater biacromial diameters and flexed arm and pectoral perimeters in the anthropometric characteristics. In body composition, men had more kilograms of muscle mass and residual mass; despite this, there were no differences in percentage values of body composition. Previous research has demonstrated that male surfers typically exhibit greater skeletal muscle mass and superior relative strength compared to their female counterparts (Janssen *et al*., 1985). In the study by da Silva & Clemente (2019), women presented significantly higher values of fat mass, differences that were not found in our study. Precisely in the study of Silva & Clemente (2019), the percentage of fat mass was 26.48 ± 4.92, while, in the study of Barlow *et al*. (2016), lower values with 18.19 ± 3.97., and in our study the female surfers had a percentage of fat mass of 21.8 ± 5.7, between those two values. According to Barlow *et al.* (2016), in female surfers, a trend towards lower levels of body fat and an increase in muscle mass could be due to the demands of competing under current evaluation criteria, which have shifted from scoring “grace and fluidity” to exhibiting power (Association of Surfing Professionals, 2013). Furthermore, Barlow *et al*. (2016), confirm that, according to their results, adiposity is negatively associated with national ranking success in female surfers. However, Furness *et al*. (2018), have suggested that an extremely low body fat level might not improve surfing performance, not only from a physical but also an energetic point of view. Therefore, body fat levels should be within a specific range (e.g., 10.5-22 % for men and women according to the literature review by Furness *et al*. (2018), but neither too high nor too low. Furthermore, Coyne *et al*. (2016), suggested that there is a threshold weight for fat-free mass above which performance improvements will be hindered., even if the athlete is very lean the paddling performance could decrease due to the additional weight (Klingner *et al*., 2022)

On the other hand, the somatotype in the female surfers in our study was mesoendomorphic (endomorphism: 4.2 ± 1.2; mesomorphism: 4.2 ± 0.4; ectomorphism:1.8 ± 0.5), similar to results of elite female surfers in the study by Barlow *et al*. (2016), (endomorphism: 4.06 ± 1.28; mesomorphism: 4.02 ± 1.00; ectomorphism: 2.01 ± 0.97). In our study female surfers had a higher level of endomorphism component than male surfers, demonstrating higher relative fatness. In the systematic review by Martínez-Mireles *et al*. (2025), female athletes in individual sports exhibited a central somatotype, including gymnasts, speed rowing athletes and dancers specialized in ten and Latin dance, evidencing that in individual sports specific somatotypes and physical characteristics are observed, reflecting a trend towards specialized body compositions that meet the physiological demands of each discipline. Regarding somatotype, in men, Valdés & Guzmán-Venegas (2016) showed a balanced mesomorphism in elite surfers (endomorphism: 2.7 ± 0.5, mesomorphism: 4.6 ± 0.7 and ectomorphism: 2.3 ± 0.6), and the surfers in our study an ectomesomorphic somatotype (2.1 ± 0.6, mesomorphism: 5.0 ± 0.9 and ectomorphism: 2.7 ± 0.5). Martinez-Mireles *et al*. (2025), showed that male athletes in individual sports predominantly exhibited an endomorphic mesomorphic somatotype including surfers, consistent with the requirements of elite male surfers who are characterized by high levels of strength, power, speed and endurance, essential for explosive movements, sustained paddling and the overall physical robustness required for surfing (Barlow *et al*., 2014; Tran *et al*., 2015; Martinez-Mireles *et al*., 2025).

In physical fitness the surfers in our study presented higher CMJ (unilateral) jumping, hand grip strength, maximal IMPT strength, and isometric shoulder strength than women. Similar results were presented by Fernandez-Gamboa *et al*. (2017), who showed that men had higher CMJ values than women. These findings are consistent with previous research, in which men had greater eccentric and concentric strength and power and greater maximal power during the concentric phase of CMJ compared to women (McMahon *et al*., 2017; Rice *et al*., 2017). Parsonage *et al*. (2017) found that female surfers had higher maximal force production (28.5 %) and jumping (27.7 %) in the SJ, and higher normalized maximal force during IMTP (18.9 %) compared to male surfers. Based on these results, considering that surfing is practiced in the same environmental conditions and the sport-specific requirements are the same for both sexes, female surfers exhibit reduced lower-body strength compared to males (Fernandez-Gamboa *et al*., 2017), implying that female surfers are at a disadvantage in their sport when trying to compete for wave quantity and quality against male surfers. Therefore, lack of upper body strength may underpin their lower paddling performance (Parsonage *et al*., 2017). On the other hand, although in our study there were no differences in stability between men and women, del Estal *et al*., (2017) showed that surfers present greater balance in relation to other athletes, possibly because it is a sport practice that is performed in an unstable environment, which demands continuous postural control adjustments. In addition, poor balance is associated with an increased risk of lower limb injury (McGuine *et al*., 2000).

Finally, there is no research comparing hamstring strength in surfers by sex. Assessing isometric hamstring strength may allow us to identify those athletes with higher levels of post-competition fatigue (and higher risk of hamstring injury), or to assess whether strength is optimally recovered after injury (McCall *et al*., 2015). In our study, differences can be observed in the right leg at 30° (men: 310.4 ± 46.4; women: 223.2 ± 14.7), and left leg (men: 282.4 ± 30.3 and women: 212.3 ± 7.3), with men presenting higher hamstring strength values than women ($p<0.005$). It is important to note that the biceps femoris muscle is maximally activated between 15° and 30 knee flexion (from full knee extension). In comparison, between 90° and 105 knee flexion are the angles at which the semimembranosus and semitendinosus muscles are maximally activated (Onishi *et al*., 2002). In addition, it has been shown that there is greater posterior chain activation with a lower degree of knee flexion (30° vs. 90°), possibly because the hamstring muscle is more elongated (Read *et al*., 2019), evidencing that male surfers have more biceps femoris strength and greater posterior chain activation than female surfers.

Practical Applications

Technical teams must assess and target the most performance-critical strength deficits in female surfers. This requires implementing personalized and periodized strength and power training programs, focusing especially on improving lower body dynamic strength, lower limb asymmetry, and postural control. In addition, they should control the surfer's proportion of fat mass to achieve better competitive results.

CONCLUSION

It is concluded that men have different anthropometric characteristics than women, having greater ectomorphy and less endomorphy. In addition, men have higher levels of hand grip strength, mobility, and stability. The findings of this study provide us evidence-based guidance for developing sex-specific training strategies to optimize anthropometric characteristics and physical performance in surf athletes.

CURRIPAN, S.; VALENZUELA-GALLEGUILLOS, E.; GARCIA-CARRILLO, E.; VÁSQUEZ BONILLA, A.; CORTÉS-ROCO, G.; VIZCAYA-DE LA PARRA, J.P.; AGUILERA-MARTÍNEZ, N.; HERRERA-AMANTE, C. & YÁÑEZ SEPÚLVEDA, R. Características antropométricas y de aptitud física de surfistas juveniles de élite chilenos. *Int. J. Morphol., 43(5)*:1733-1741, 2025.

RESUMEN: Las características antropométricas y de aptitud física influyen significativamente en el rendimiento en el surf. A pesar de esta importancia, los perfiles antropométricos de los surfistas juveniles de élite siguen estando poco caracterizados en la literatura científica. El objetivo del estudio fue analizar las características antropométricas y condición física en surfistas elite juniors según sexo. Participaron del estudio 8 surfistas del programa gubernamental Promesas Chile (5 hombres: 18.8 ± 3.0 años, y 3 mujeres 20.2 ± 4.2 años). Se evaluaron características antropométricas, somatotipo, fuerza muscular, potencia de miembros inferiores, movimiento funcional y estabilidad. Los resultados mostraron diferencias en los kilogramos de masa muscular ($p=0.036$) siendo los hombres quienes presentaron mayor nivel 35.2 vs 25.6 kg. Los hombres presentaron un mayor salto CMJ en la pierna derecha ($p=0.036$), y en la prensión manual de mano derecha e izquierda ($p=0.036$), el IMPT fue mayor en hombres en comparación con las mujeres. El somatotipo de los hombres fue Ecto-Mesomorfo (2.1-5-0-2.7) y el de las mujeres fue Mesomorfo-Endomorfo (4.2-4.2-1.8). Además, los hombres presentaron mayores niveles de fuerza isométrica de hombros que las mujeres. También los hombres presentaron mayor nivel de fuerza isométrica de la cadena posterior a los 30°. Se concluye que los hombres presentan características antropométricas diferentes a las mujeres siendo estos quienes presentan mayor ectomorfia y menor endomorfia, además los hombres tienen mayores niveles de fuerza de prensión manual, movilidad y estabilidad. Los resultados del presente estudio permiten orientar estrategias de entrenamiento diferenciados según sexo para optimizar las características antropométricas y rendimiento físico en los deportistas.

PALABRAS CLAVE: Surf; Ejercicio; Rendimiento; Composición corporal; Antropometría.

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