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Morphological and performance characteristics of elite Colombian speed skaters

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Abstract

Background: Inline speed skating demands explosive strength and specific anthropometric profiles, yet studies on sex-based morphological and functional differences among Latin American skaters are scarce. This exploratory cross-sectional study aimed to characterize physical performance and anthropometric variables by sex in elite Colombian junior inline speed skaters.
Aims: The primary objective of this exploratory cross-sectional study was to characterize the anthropometric profiles and physical performance variables by sex in a sample of elite Colombian junior inline speed skaters.
Methods: Twenty-three elite skaters (12 females, 11 males; aged 16-21 years) were assessed. Anthropometric profiling followed ISAK guidelines, measuring skinfolds, girths, and breadths. Physical performance and explosive strength were evaluated using various jump tests (SJ, CMJ, SLCMJ, and continuous jumps) via the My Jump Lab application.
Results: Marked sexual dimorphism was observed in body composition: females exhibited higher subcutaneous adiposity (fat mass), whereas males demonstrated greater muscle mass and skeletal robustness. However, differences in explosive performance and functional metrics between sexes were unexpectedly modest.
Conclusions: Elite female skaters achieve functional outcomes comparable to those of males despite marked morphological differences. These findings indicate that higher body fat limits jumping capacity, highlighting the need for systematic body composition monitoring and the development of sex-specific training strategies.

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INTRODUCTION

Inline skating is characterized as a sport that combines the expression of physical capacities, particularly those associated with muscular strength, as a key indicator of performance (Suchomel et al., 2016). These physical capacities are essential for athletes to adapt to the demands of competition in cyclic sports (Carvalho de Moura et al., 2025), given that maintaining balance on skates is a variable and complex process (Vila et al., 2007). To achieve this, skaters rely on explosive strength aligned with the rhythm of competition, as it is a sport in which biological characteristics and energy reutilization predominate (Chen et al., 2019). Because inline speed skating includes race formats of varying distances, energy distribution is associated with the specific actions performed during competition to achieve high velocity and optimal balance (Becerra-Patiño et al., 2022; Smits et al., 2014). These capacities are linked to unilateral strength and hamstring musculature, which are essential for accelerating on straightaways or decelerating through turns (Kellis & Blazevich, 2022; Wu et al., 2025). Some studies have demonstrated that in time-trial sports, physical performance depends on an athlete's capacity to reutilize energy (Foster et al., 2003; Van Ingen Schenau et al., 1992). Therefore, characterizing physical fitness variables in skaters is necessary to align training with the specific demands of the sport, and more importantly, to understand the athlete's needs (Hernández Beltrán et al., 2025; Davis et al., 2024).

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In longer events such as 3000, 5000, and 10,000 meters, skaters must combine various physical capacities, notably power, strength, speed, endurance, and flexibility (Peng et al., 2022). Likewise, given the sport's unique energy demands, skaters must adopt strategic positioning during competition (Ichinose et al., 2020) to maximize performance in line with their morphological and functional capacities (Furrer et al., 2023). Additionally, some studies report that skaters tend to have a small, athletic build (Matyk & Raschka, 2012), while others suggest that body composition varies with age and competitive level (Lozada-Medina & Padilla-Alvarado, 2020; Becerra-Patiño et al., 2025). To maintain the race pace, skaters must perform constant acceleration and push-off actions (Deguire et al., 2023), as the sport requires continuous changes in altitude and numerous intensity fluctuations, including short efforts (<10 s), moderate efforts (30 s–2 min), and long efforts (>2 min) (Falk Neto et al., 2024).

The exploratory systematic review conducted by Wu et al. (2025) concluded that it is essential to understand the factors and variables that determine performance in inline speed skating, beyond extrapolating research paradigms from similar sports such as ice speed skating. Thus, characterizing how physical variables are assessed using Squat Jumps (SJ), Countermovement Jumps (CMJ), Single-Leg Countermovement Jumps (SLCMJs), and continuous jumps, in relation to anthropometric variables, is necessary to guide training processes and sports performance. According to Warr et al (2022), jumping ability is a factor closely associated with sports performance, particularly when considering the muscular force generated by the lower limbs in cyclic sports (Zukowski et al., 2023, 2024). Jump tests provide an objective assessment of functional performance and offer insights into sport-specific movements (Donskov et al., 2021; Sánchez et al., 2024). Other studies have reported that SJ performance is linked to better execution in actions requiring speed and technical precision (Invernizzi et al., 2019). These actions stem from muscular activation of the lower limbs, particularly during straights and turns, making the expression of strength fundamental for high performance in a sport that demands high efficiency (Felser et al., 2016).

Similarly, SLCMJs serve as an objective measure for evaluating capacities related to power, strength, and speed actions that are essential in roller sports (Donskov et al., 2021). Research on asymmetries in sports performance, particularly lower-limb asymmetries, has shown that increased asymmetry can negatively affect athletic performance (Jin et al., 2025; Monterrosa. A & Pereira-Moro, 2020), and some studies have associated these asymmetries with competitive outcomes (Liu et al., 2024; Stadnyk et al., 2023). In inline speed skating, actions during the propulsive phase induce fatigue indices resulting from unilateral force production (Bongiorno et al., 2023; Pethick & Tallent, 2022). Therefore, assessing jump-related variables is essential for understanding athletes' performance and the training load imposed (Silva et al., 2015).

In addition, other studies have examined changes in body composition across different seasons among speed skaters, showing that seasonal variations in anthropometric variables reflect fluctuations in training load (Varley et al., 2019). This suggests that scientific evidence must aim to understand how physical and anthropometric variables relate in skaters from different geographic and competitive environments. Various anthropometric variables, including body mass, muscle mass, and body fat percentage, have been shown to correlate with race time (Knechtle et al., 2011), while other variables, such as sex, show clear differences among skaters (David et al., 2025). For example, Stoter et al (2020) identified sex-based differences in push-off angles, and another study analyzing sex differences in endurance Olympic sports concluded that women exhibit a lower performance primarily due to reduced propulsive capacity during racing (Solli et al., 2024).

Despite the range of race modalities, inline speed skating still exhibits a low volume of scientific research compared to other sports, making continued research essential to deepen understanding of its physiological and biomechanical demands. Addressing this gap is particularly relevant in the Colombian context. Therefore, descriptively characterizing the anthropometric profiles and specific jump-derived metrics of these elite athletes is essential to directly inform talent identification, optimize training load management, and provide valuable reference data for the scientific community.

METHOD

Research Design

This study employed a cross-sectional descriptive design (O'Donoghue, 2010). Its purpose was to characterize physical performance variables and body composition indicators in a sample of elite Colombian speed skaters. Before all assessments, the participants read an informed consent document describing the benefits and risks of their participation in the study and voluntarily signed to indicate their agreement.

All procedures complied with the World Medical Association (2025) and local regulations for human subject research (Resolution 8430/1993, Colombia), ensuring data protection and confidentiality. The study protocol was classified as minimal risk. All tests were conducted at the same time of day (16:00 to 18:00) and under identical environmental conditions (average temperature: 13.1 °C; humidity: 77–83%). The assessments were performed following a specific warm-up protocol consisting of continuous running exercises of 45 seconds of work and 15 seconds of recovery, organized into five stations with minor variations. After completing the five stations, the circuit was repeated. Each testing day was separated by at least 48 hours to avoid fatigue. Likewise, assessments were scheduled two days before and two days after the weekend to minimize accumulated fatigue and ensure at least one rest day.

All evaluations were conducted by personnel experienced in the use of the applications and certified by the International Society for the Advancement of Kinanthropometry (Esparza-Ros et al., 2019) to minimize measurement bias. Each participant was summoned 60 minutes before the start of the training session and organized into groups of 4 athletes.

Before starting the assessments, the research team was fully familiarized with the protocols, applications, and procedures for both physical and anthropometric testing, thereby reducing potential sources of bias. Once the physical and/or anthropometric tests were completed, the research team downloaded the data to a laptop computer. It exported them into an Excel spreadsheet to create the database before statistical processing.

Participants

Given the final sample size (n = 23) and the large number of variables assessed, this study is positioned as exploratory rather than confirmatory. Furthermore, the age range of 16–21 years introduces potential variations in biological maturation, which must be considered a confounder when interpreting the results. To be included in the study, participants had to meet the following inclusion criteria: (i) absence of musculoskeletal injuries during the three months preceding testing or having completed a postoperative recovery process within the last six months with medical clearance; (ii) absence of muscle discomfort at the time of testing; (iii) a minimum of two years of skating experience and membership in a national-level team; (iv) training at least five times per week; (v) participation in at least three national competitions; (vi) being within the age range of 16 to 21 years; and (vii) provision of assent and/or informed consent. The exclusion criteria were: (i) the presence of underlying pathological conditions preventing physical exertion; and (ii) failure to complete all evaluations included in the study. It is important to highlight that these 23 athletes represent the entire cohort of elite junior inline speed skaters in Bogotá, the capital of Colombia, who met all the aforementioned criteria at the time of the study, making this sample highly representative of this highly specific athletic population. This study was conducted during the early phase of the competition season, before the national tournament began. The main characteristics of the selected sample are presented in Table 1.

Table 1. Main Characteristics of the Sample

Variable	Female (n = 12)	Male (n = 11)
Age (years)	18.38 ± 1.67	17.85 ± 1.28
Weight (kg)	54.58 ± 5.85	60.09 ± 7.44
BMI (kg/m^2)	21.11 ± 1.54	21.16 ± 1.56
Height (cm)	160.51 ± 6.75	168.42 ± 6.77
Sports experience (years)	6.6	6.9

The instrument used in this study was a digital scale (OMRON HBF-514, Kyoto, Japan) to measure body mass and additional bioimpedance variables. Height was measured using a portable stadiometer (Seca 213, Hamburg, Germany). Muscular performance tests included various jumps, SJ, CMJ, SLCMJs, and continuous jumps. These assessments were performed using the My Jump Lab application with an iPhone 14 (Apple Inc., Cupertino, CA, USA) (Balsalobre-Fernández et al., 2015). Body composition was evaluated via anthropometry. Physical fitness assessments aimed to evaluate the athletes' physical performance. The testing protocol followed the procedures of a previous study that evaluated the same physical variables (Becerra Patiño et al., 2025).

On the first day, strength tests were performed (SJ, CMJ, SLCMJs). On the second day, continuous jumps were completed. The squat jump (SJ) aims to assess maximal jump height with the hands placed on the hips throughout the movement. The SJ evaluates take-off quality and the athlete's ability to generate explosive force. Before jumping, the participants maintained a squat position for 3 seconds (Gupta et al., 2023). Counter Movement Jump, the countermovement jump (CMJ) evaluates the use of elastic energy and the athlete's ability to produce force over a longer duration compared to the SJ.

During the execution, the participants kept their hands on their hips (Cormack et al., 2008). Single-leg countermovement jumps (SLCMJs assess unilateral muscular force and performance. Variables such as flight time asymmetry, flight time, and push-off distance are used to identify muscular imbalances. The test was performed with the participant standing on a 20-cm box while keeping their hands on their hips throughout the motion (Bishop et al., 2020).

Continuous jumps: This test evaluates repeated jump power. Participants were encouraged to perform at least 10 jumps within 10 seconds, using their arms to generate propulsion and minimizing ground contact time. Data from 10 jumps were collected (Robert et al., 2020). Testing sessions were separated by 48 hours. For all jump assessments, the recording device was placed two meters from the athlete's jumping area. Below are descriptions of the tests and variables obtained, following the order in which they were conducted during the study, with two minutes of passive recovery between each test (Heishman et al., 2020). Assessment of anthropometric variables each anthropometric measurement included height, weight, height at 90°, leg length, lever arm, skinfold thickness (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh, calf), bone breadths (humerus, bi-styloid, femur), and muscular girths (relaxed arm, flexed arm, waist, hip, thigh, calf). These assessments were conducted by ISAK-certified personnel following standardized protocols. All measurements were taken in duplicate to ensure accuracy, and the mean value was used for analysis.

Analysis

Data were analyzed using Jamovi version 2.3.28 (The Jamovi Project, 2024). Given the small sample size (total n = 23; females, n = 12; males, n = 11) relative to the large number of anthropometric and performance variables assessed, this study is explicitly positioned as an exploratory pilot dataset. Consequently, traditional inferential statistics and significance testing (p-values) were intentionally omitted to mitigate the inherent risk of both Type I (false positives) and Type II (false negatives) errors. The primary basis for data interpretation relies strictly on descriptive statistics (mean ± standard deviation) to characterize the sample.

RESULTS AND DISCUSSION

Results

In this study of elite juvenile speed skaters (n = 23; females, n = 12; males, n = 11), comprehensive assessments revealed pronounced sexual dimorphisms at a descriptive level. Table 2 presents the descriptive statistics (mean ± standard deviation) of 26 sociodemographic and body composition variables by sex. Similarly, Table 3 presents the descriptive profile of 54 physical performance metrics, categorized by the specific types of jumps performed (squat jump, countermovement jump, countermovement jump with arm swing, single-leg countermovement jump, and repeated jumps), along with contact times and hamstring strength.

Sociodemographic and Body Composition Profile

Regarding the basic anthropometric measures (Table 2), male and female skaters presented similar ages and body mass indices. However, a marked sexual dimorphism was evident in body composition. Males exhibited substantially greater skeletal robustness, as indicated by larger bone diameters and a notably higher relative muscle mass than females. Conversely, female athletes displayed greater subcutaneous adiposity, as reflected in a higher overall body fat percentage and consistently thicker skinfolds, particularly in the triceps, abdomen, and thigh regions. Despite these marked differences in fat and muscle distribution, several muscular circumferences remained relatively comparable between both sexes.

Table 2. Descriptive Characteristics by Sex (Mean ± SD)

Variable	Female (n = 12)	Male (n = 11)
Basic measures		
Age (years)	18.38 ± 1.67	17.85 ± 1.28
Body mass (kg)	54.58 ± 5.85	60.09 ± 7.44
BMI (kg/m^2)	21.11 ± 1.54	21.16 ± 1.56
Fat (%)	29.56 ± 4.00	13.81 ± 2.71
Muscle (%)	27.56 ± 2.56	49.72 ± 14.78
Height (cm)	160.51 ± 6.75	168.42 ± 6.77
Leg length (cm)	97.54 ± 6.11	103.91 ± 5.08
Height at 90° (cm)	70.58 ± 12.39	67.82 ± 11.26
Lever arm (cm)	120.47 ± 5.06	124.61 ± 6.39
Skinfolds (mm)		
Triceps	12.00 ± 2.93	5.86 ± 1.46
Subscapular	10.50 ± 2.65	7.73 ± 1.93
Biceps	4.72 ± 1.09	3.24 ± 0.57
Iliac crest	11.22 ± 3.12	9.78 ± 3.30
Supraspinal	8.93 ± 2.91	7.22 ± 2.20
Abdominal	13.12 ± 4.81	8.49 ± 2.50
Thigh	13.14 ± 5.20	7.84 ± 2.97
Calf	8.18 ± 2.72	5.79 ± 1.53
Circumferences (cm)		
Relaxed arm	24.12 ± 1.65	24.76 ± 1.85
Flexed arm	24.33 ± 1.43	27.05 ± 1.82
Waist	66.95 ± 2.79	69.92 ± 3.08
Hip	90.61 ± 5.46	89.71 ± 5.06
Thigh	51.37 ± 3.56	50.22 ± 3.20
Calf	32.75 ± 1.99	33.13 ± 2.41
Diameters (cm)		
Humerus	5.97 ± 0.30	6.75 ± 0.34
Bi-styloid	4.81 ± 0.26	5.41 ± 0.25
Femur	7.97 ± 0.37	9.43 ± 0.42

Note. *Values are presented as mean ± standard deviation (SD). BMI = body mass index.*

Table 3 details the physical performance metrics across the various jump tests. Interestingly, despite the pronounced morphological differences described above, the disparities in explosive performance were relatively modest. Across the bilateral vertical jump variations (SJ, CMJ, and CMJA), males consistently achieved slightly greater jump heights and longer flight times than females. Furthermore, males demonstrated greater horizontal displacement during the propulsion phase, as evidenced by longer push-off distances. Unilateral jump assessments (SLCMJ) revealed that both sexes exhibited similar, low asymmetry indices (approximately 6%). Finally, the evaluation of hamstring strength indicated greater torque production in male skaters, although the break angles were highly consistent between both groups.

Table 3. Jump Performance Characteristics by Sex

Variable	Female (n = 12)	Male (n = 11)
	Squat jump (SJ)	
Push-off distance (m)	0.28 ± 0.11	0.37 ± 0.10
Jump height (cm)	30.92 ± 8.68	37.06 ± 8.05
Flight time (ms)	487.53 ± 86.07	531.40 ± 93.55
Force (N)	1393.33 ± 877.71	1170.80 ± 219.48
Velocity (m/s)	1.17 ± 0.24	1.30 ± 0.23
Power (W)	1705.68 ± 1226.82	1536.28 ± 459.43
	Countermovement jump (CMJ)	
Push-off distance (m)	0.30 ± 0.10	0.37 ± 0.10
Jump height (cm)	31.09 ± 11.42	38.06 ± 12.69
Flight time (ms)	493.40 ± 104.71	548.83 ± 100.59
Force (N)	1425.45 ± 946.52	1210.73 ± 238.63
Velocity (m/s)	1.21 ± 0.26	1.35 ± 0.25
Power (W)	1798.41 ± 1378.02	1643.99 ± 526.66
	CMJ with arm swing (CMJA)	
Push-off distance (m)	0.27 ± 0.12	0.37 ± 0.10
Jump height (cm)	33.54 ± 11.52	41.61 ± 13.39
Flight time (ms)	513.54 ± 103.26	574.13 ± 103.23
Force (N)	1468.82 ± 978.70	1268.54 ± 247.55
Velocity (m/s)	1.26 ± 0.25	1.41 ± 0.25
Power (W)	1928.41 ± 1421.15	1798.30 ± 549.15
	Single-leg CMJ (SLCMJ)	
Asymmetry flight time (%)	6.21 ± 4.66	5.82 ± 6.77
Flight time left (ms)	295.75 ± 59.93	322.09 ± 72.21
Jump height left (cm)	11.13 ± 4.27	13.31 ± 5.38
Force left (N)	719.16 ± 765.07	810.25 ± 145.53
Power left (W)	529.33 ± 564.65	648.50 ± 214.98
Velocity left (m/s)	0.72 ± 0.15	0.79 ± 0.18
RSI left (m/s)	1.01 ± 0.25	1.13 ± 0.28
Flight time right (ms)	308.25 ± 64.09	328.27 ± 63.47
Jump height right (cm)	12.11 ± 5.10	13.66 ± 4.98
Force right (N)	746.20 ± 814.40	821.09 ± 152.89
Power right (W)	585.44 ± 649.30	667.47 ± 209.36
Velocity right (m/s)	0.76 ± 0.16	0.80 ± 0.16
RSI right (m/s)	1.00 ± 0.29	1.08 ± 0.28
	Repeated jumps (10 jumps)	
RSI 10–5	0.68 ± 0.14	0.71 ± 0.17
Jump 1 (cm)	33.54 ± 6.65	37.86 ± 8.34
Jump 2 (cm)	33.53 ± 7.43	38.72 ± 8.21
Jump 3 (cm)	34.49 ± 7.10	37.41 ± 7.75
Jump 4 (cm)	34.61 ± 6.26	37.36 ± 8.34
Jump 5 (cm)	33.45 ± 7.14	36.48 ± 8.07
Jump 6 (cm)	32.50 ± 6.63	36.01 ± 7.48
Jump 7 (cm)	33.01 ± 6.44	35.81 ± 7.22
Jump 8 (cm)	33.12 ± 7.45	36.43 ± 7.61
Jump 9 (cm)	32.77 ± 7.08	35.93 ± 8.27

Variable	Female (n = 12)	Male (n = 11)
Jump 10 (cm)	32.82 ± 7.42	35.91 ± 8.48
	Contact time (ms)	
Contact time 1	508.10 ± 66.83	558.80 ± 43.77
Contact time 2	524.90 ± 31.47	542.90 ± 50.67
Contact time 3	522.40 ± 51.48	548.50 ± 59.60
Contact time 4	515.05 ± 56.72	555.92 ± 49.67
Contact time 5	519.77 ± 48.45	557.58 ± 55.56
Contact time 6	533.24 ± 45.27	557.28 ± 53.96
Contact time 7	541.71 ± 51.63	565.46 ± 51.54
Contact time 8	537.96 ± 41.84	561.98 ± 49.56
Contact time 9	555.31 ± 41.72	562.28 ± 68.20
Contact time 10	551.01 ± 44.44	577.27 ± 57.39
	Hamstring strength	
Torque (Nm)	339.63 ± 168.99	370.33 ± 91.80
Break angle (°)	133.18 ± 10.96	135.90 ± 9.36

Note. *Values are presented as mean ± standard deviation. SJ = squat jump; CMJ = countermovement jump; CMJA = countermovement jump with arm swing; RSI = reactive strength index.*

Discussion

The primary objective of this study was to characterize the anthropometric and physical performance profiles of elite Colombian junior inline speed skaters, with the findings presented as an exploratory dataset. Given the limited scientific literature on Latin American inline skaters, these descriptive data make a novel contribution by enabling a direct comparison between this cohort and the established global morphological and functional profiles of skaters.

Anthropometric variables

The findings of the present study revealed a significant sexual dimorphism in body composition and anthropometric characteristics among elite Colombian inline speed skaters (Table 2) in key variables such as body mass (females: 54.58 ± 5.85 vs males: 60.09 ± 7.44), percentage fat mass (females: 29.56 ± 4.00 vs males: 13.81 ± 2.71) and percentage muscle (females: 27.56 ± 2.56 vs males: 49.72 ± 14.78). These findings highlight the differences observed in other studies in similar sports, where it was reported that, although there are marked differences between the sexes, particularly in body composition (Hunter et al., 2023), these differences tend to decrease when evaluating athletes' performance within the same event or sport (Joyner et al., 2025; Hunter & Senefeld, 2024). However, the data from the present study revealed substantial differences, underscoring the importance of characterizing this sport in Colombia to understand its needs.

Other variables assessed using anthropometry showed contrasting values between the men and women evaluated in this study, particularly about skinfold thickness, where biceps skinfold thickness (females: 12.00 ± 2.93 vs. males: 5.86 ± 1.46 mm), subscapular (females: 10.50 ± 2.65 vs. males: 7.73 ± 1.93), abdominal (females: 13.12 ± 4.81 vs. males: 8.49 ± 2.50 mm), and thigh (females: 13.14 ± 5.20 vs. males: 7.84 ± 2.97 mm) skinfolds, showed higher values in women than in men. These results are consistent with those reported in other studies that assessed the anthropometric profiles of elite figure skaters, which found differences in the sum of 4 skinfolds (females: 36.6 ± 6. 4 vs. males: 57.2 ± 17.2 mm) and the sum of 6 skinfolds (females: 67.8±14.5 vs. males: 108.4±30.1 mm), with women exhibiting higher values (Vila et al., 2013). Furthermore, among the anthropometric variables evaluated, this is the one with the least daily variability (Kasper et al., 2021), supporting its use in studies comparing these measurements across genders.

Along the same lines, another study by Vila et al. (2015) involving figure skaters, sought to determine differences in skinfold thicknesses by discipline, evaluating skaters in figure skating, freestyle, pairs, and ice dancing, and concluding that there are differences in skinfold thicknesses, particularly in the sum of the four skinfolds (Figure: 35.9 ± 6.4 vs. Freestyle: 33.5 ± 12.9 mm) and the sum of six skinfolds (Dance: 68.5 ± 19.1 vs. Freestyle: 58.1 ± 21.7 mm). These differences in skinfold measurements indicate that this variable varies not only by gender but also by sport modality, underscoring the need to assess and monitor it throughout skaters' athletic and competitive careers.

The superior skeletal robustness observed in males, with bone diameters that were 12–14% larger, aligns with universal sex differences in endurance athletes, where males exhibit approximately 15% greater cortical bone cross-sectional area in the lower limbs (Handelsman et al., 2018). However, in elite speed skaters, this difference decreases in the femur after prolonged training (Varley et al., 2019), suggesting an untapped potential for optimization in Latin American contexts through progressive mechanical loading. The extreme disparities in adiposity and relative muscle mass, which exceeded those reported in European female ultra-distance inline skaters (Knechtle et al., 2011), underscore the urgent need for sex-specific reference values in Colombian speed skating and highlight the value of considering body composition in training programs, as excess fat may be negatively associated with performance in short- and middle-distance events (Lozada-Medina & Padilla-Alvarado, 2020).

Conversely, the females' markedly higher body fat percentage appeared not to impose the expected penalty on explosive performance to the degree observed in European cohorts (Matyk & Raschka, 2012). Longitudinal interventions combining high-velocity strength training and body-composition optimization are warranted to determine whether closing these morphological gaps can yield larger, functionally relevant performance divergences in this population."

Performances variables

Despite the marked sexual dimorphism observed in body composition and skeletal robustness, the translation of these morphological advantages into physical performance was unexpectedly modest in this cohort of elite Colombian inline speed skaters. Nevertheless, the takeoff distance in the SJ (Females: 0.28 ± 0.11 vs. males: 0.37 ± 0.10), the CMJ (Females: 0.30 ± 0.10 vs. Males: 0.37 ± 0.10), and CMJA (Females: 0.27 ± 0.12 vs. males: 0.37 ± 0.10), which describes the horizontal displacement of the center of mass during the propulsion phase, showed notable disparities based on sex. This parameter remained consistently higher in men across all jump conditions (SJ, CMJ, and CMJ), reflecting a physiological trend related to greater absolute leg length, larger femoral diameters, and a substantially higher percentage of muscle mass. These attributes facilitate a longer effective lever and greater application of horizontal force, factors known to correlate with track acceleration and maximum speed in speed skating (van Ingen Schenau et al., 1995).

Similarly, traditional vertical jump parameters (height, flight time, peak power, and velocity) showed trends favoring men. The most representative variables of the jumps evaluated were height and power; it was found that both men and women exhibited similar values in the standing long jump (women: 30.92 ± 8.68 vs. men: 37.06 ± 8.05) and CMJ (women: 31.09 ± 11.42 vs. men: 38.06 ± 12.69 cm), which highlights a lower level of neuromuscular strength development based on sex. In the present study, it was determined that male skaters jumped, on average, slightly higher than women. This observation is consistent with reports on track speed skating, in which men showed a CMJ height of 31.8 ± 4.2 cm compared with 28.5 ± 4.8 cm for women (Haugen et al., 2020). One explanation for these differences may be differences in muscle volume, an important factor in gender differences in vertical jump performance (Bchini et al., 2023).

Taken together, these performance data reveal a paradoxical pattern: Colombian elite male skaters possess morphological advantages, yet these translate into only moderate functional advantages, primarily in horizontal force application and initial reactive strength (Lozada-Medina & Padilla-Alvarado, 2020). This dissociation suggests that current training practices in Colombian elite programs may not fully exploit males' structural potential, particularly in rate of force development and stretch-shortening cycle efficiency.

Another important variable that showed differences among the skaters evaluated was the assessment of the hamstrings, specifically in terms of torque (Females: 339.63 ± 168.99 vs. Males: 370.33 ± 91.80 Nm), although the failure angles were similar (Females: 133.18 ± 10.96 vs. Males: 135.90 ± 9.36°). These differences in the hamstring-to-quadriceps ratio have been reported as an indicator of why women are more prone to knee injuries (Heinert et al., 2021). A study comparing the hamstring-to-quadriceps ratio across the entire speed spectrum concluded that men exhibit higher hamstring-to-quadriceps ratios throughout the speed range, providing a biomechanical advantage for athletic performance and injury prevention (Searles et al., 2025).

Implications

This study provides a significant contribution to the limited body of scientific literature regarding Latin American, and specifically Colombian, elite inline speed skaters. By establishing an exploratory descriptive dataset of anthropometric and physical performance profiles, it serves as a novel reference framework for sports scientists and coaches working with elite junior cohorts. The primary practical implication of these findings is the identification of a dissociation between morphological characteristics and functional performance, despite male skaters possessing significant structural advantages, including greater relative muscle mass and skeletal robustness. These do not translate proportionally into a massive advantage in explosive jump performance. This suggests that current training programs may not fully exploit the neuromuscular and structural potential of these athletes. Furthermore, the findings highlight the necessity of implementing sex-specific training strategies. For female athletes, systematic monitoring of body composition is crucial to minimize the negative impact of excess fat mass. In contrast, for male athletes, training should emphasize optimizing the stretch-shortening cycle and rate of force development. Ultimately, these insights can directly inform talent identification processes and the optimization of training loads in this highly specific athletic population.

Research Contributions

This study provides a significant contribution to the limited scientific literature on Latin American elite inline speed skaters by establishing a novel reference framework of anthropometric and physical performance profiles for junior cohorts. The research identifies a critical dissociation between morphological characteristics and functional performance, demonstrating that although male skaters possess significant structural advantages, such as greater relative muscle mass and skeletal robustness. These do not translate proportionally into a massive advantage in explosive jump performance. These findings highlight the necessity of implementing sex-specific training strategies, such as systematic body composition monitoring for females to minimize the negative impact of excess fat mass and optimizing the stretch-shortening cycle and rate of force development for males. Ultimately, these insights can directly inform talent identification processes and the optimization of training loads in this highly specific athletic population.

Limitations

Although the small sample size (n=23), combined with a high volume of statistical tests, increases the risk of false positives, this number reflects the actual population of elite skaters in Bogotá who met the rigorous criteria, rather than a lack of recruitment. Additionally, the age range (16–21 years) suggests that biological maturation could be a confounder. Finally, the highly specific context of national-level Colombian skaters limits the external validity of these findings. Despite Colombia being a traditional country in inline speed skating, there is still limited scientific literature on the sport, which limits the ability to compare and contextualize findings.

Suggestions

To address these limitations, future research should aim to replicate this exploratory study across different age categories, competitive levels, and geographic regions to improve external validity. Furthermore, longitudinal interventions combining high-velocity strength training and body-composition optimization are highly recommended. Such studies are warranted to determine whether closing the morphological gaps between sexes can yield larger, functionally relevant performance divergences in this specific athletic population.

CONCLUSION

In this cohort of elite junior skaters, sex-based differences were primarily evident in anthropometric characteristics rather than in explosive performance metrics, suggesting that female athletes achieve comparable functional outcomes despite marked morphological differences. These descriptive differences highlight the need to develop sex-specific training approaches. Based on the results of this study, speed skating coaches and support staff should consider systematically monitoring both physical and anthropometric variables. This will help optimize training processes in the short, medium, and long term and will provide support during the identification and development of athletic talent.

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AUTHOR CONTRIBUTION STATEMENT

Introduction: B.A.B.-P., A.M.-Q. and DAGV.; method: B.A.B.-P.; analysis: A.M.-Q.; results: B.A.B.-P. and A.M.-Q.; discussion and conclusions: B.A.B.-P., A.M.-Q. and DAGV.; writing and preparation of the paper: B.A.B.-P., A.M.-Q. and DAGV.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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