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Countermovement Jump Performance and Sprint Speed in Chilean Adolescent Athletes: Does the Association Differ by Sex?

Claudio Hernández-Mosqueira [1,*], Pablo Luna-Villouta [2], Humberto Castillo-Quezada [3], Pedro Delgado-Floody [4], Gustavo Pavez-Adasme [5], Sebastián Peña-Troncoso [6,7], Felipe Hermosilla-Palma [8], Roberto Espinoza-Gutiérrez [9], Juan J. Calleja-Nuñez [9], Jorge A. Aburto-Corona [9] and Jorge Leschot-Gatica [10,11]

1 Departamento de Ciencias de la Educación, Universidad del Bio-Bio, Chillán 3780000, Chile
2 Departamento de Educación Física, Universidad de Concepción, Concepción 4030000, Chile; pabloluna@udec.cl
3 Facultad de Educación y Humanidades, Universidad Andres Bello, Concepción 4030000, Chile; humberto.castillo@unab.cl
4 Departamento de Educación Física, Deportes y Recreación, Universidad de La Frontera, Temuco 4811230, Chile; pedro.delgado@ufrontera.cl
5 Centro Regional de Estudios Avanzados en Estilos de Vida Activos y Saludables, Universidad Adventista de Chile, Chillán 3780000, Chile; gustavopavez@unach.cl
6 Instituto de Ciencias de la Educación, Universidad Austral de Chile, Valdivia 3780000, Chile; sebastian.pena@uach.cl
7 Departamento de Educación, Universidad SEK, Santiago 8320000, Chile
8 Pedagogía en Educación Física, Facultad de Educación, Universidad Autónoma de Chile, Talca 3460000, Chile; felipe.hermosilla@uautonoma.cl
9 Laboratorio de Biociencias de la Motricidad Humana (LABIMH), Grupo de Investigación UABC-CA-341 Rendimiento Físico, Salud y Educación Disciplinar, Facultad de Deportes Tijuana, Universidad Autónoma de Baja California, Tijuana 22000, Mexico; espinoza.roberto@uabc.edu.mx (R.E.-G.); juan.calleja@uabc.edu.mx (J.J.C.-N.); jorge.aburto@uabc.edu.mx (J.A.A.-C.)
10 Facultad de Salud y Ciencias Sociales, Universidad de Las Américas, Licenciatura en Ciencias de la Actividad Física, Concepción 4030000, Chile; jleschotg@gmail.com
11 Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción 4030000, Chile
* Correspondence: chernandez@ubiobio.cl

Abstract

Background: This study examined the relationship between countermovement jump (CMJ) performance and sprint speed in adolescent athletes, considering anthropometric variables and potential sex differences. Methods: A descriptive-correlational study was conducted with 140 athletes (43 females and 97 males, aged 14–17 years) from the Promesas Ñuble program in Chile. Body composition, biological maturation, flexibility, vertical jump performance, and 10 and 20 m sprint performance were assessed using standardized protocols. Results: CMJ performance was strongly and negatively correlated with 20 m sprint time ($r \approx -0.76$), indicating that greater jump heights were associated with faster sprint times. In the multiple linear regression analysis, CMJ emerged as the strongest predictor of 20 m sprint time, with the overall model explaining approximately 61% of the variance ($R^2 = 0.608$; adjusted $R^2 = 0.594$). A significant CMJ × sex interaction was observed in the primary analysis ($B = -0.0217$ s·cm^{-1}, 95% CI [−0.0414, −0.0019], $p = 0.032$). Sex-stratified analyses showed a negative association between CMJ and sprint time in males ($B = -0.0267$ s·cm^{-1}, 95% CI [−0.0343, −0.0190], $p < 0.001$), whereas the female-specific estimate was less precise and its confidence interval included zero ($B = -0.0240$ s·cm^{-1}, 95% CI [−0.0542, 0.0062], $p = 0.116$). However, influence diagnostics identified one valid but highly influential observation in the female subgroup (Cook's D = 1.238). In a sensitivity analysis excluding this observation, the CMJ × sex interaction was attenuated and no longer statistically significant ($B = -0.0051$ s·cm^{-1}, 95% CI [−0.0226, 0.0125], $p = 0.568$), indicating that evidence for sex-specific differences was sensitive to this observation. Conclusions: CMJ performance was strongly associated with 20 m sprint performance in adolescent athletes.

Check for updates

Academic Editor: Arkady Voloshin

Received: 26 August 2026
Revised: 30 September 2026
Accepted: 8 October 2026
Published: 30 October 2026

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Although the primary analysis suggested that this association differed by sex, sensitivity analysis showed that the interaction was substantially influenced by one valid influential observation in the female subgroup. These findings support an association between CMJ and sprint performance but indicate that sex-specific differences require confirmation in larger and more balanced samples.

Keywords: sprint; adolescents; body composition; jumps

1. Introduction

Sprint speed and lower-body power are key determinants of performance across various team and situational sports—such as soccer, basketball, handball, volleyball, and hockey—where acceleration, change-of-direction ability, and high-intensity movements are frequent and decisive [1,2]. These actions are particularly significant in young athletes because they coincide with important changes in strength, power and body composition that can influence their long-term trajectory, and talent selection and identification processes [3].

In the context of sports science, field tests allow for the rapid and reliable assessment of sprint speed and lower-limb power, making them essential for training control and monitoring physical development. Among these, short-distance sprints (e.g., 10–20 m) and the countermovement jump (CMJ) have become widely used tools in clubs and training programs due to their low cost, ease of administration, and informative value regarding explosive output [1,4].

The relationship between CMJ and sprinting has been documented in both young and adult athletes, with studies showing moderate to very high correlations between jump height and 20 to 50 m sprint times [1,5]. However, Philpott et al. [4] examined sex differences in CMJ performance among adult elite track and field athletes, including sprinters and high jumpers, rather than examining adolescent athletes. Their study focused on comparisons of CMJ performance between males and females and between athletic events; it did not investigate the relationship between CMJ performance and sprint speed or test sex as a statistical moderator of this relationship. Therefore, the present study differs from Philpott in terms of the age and competitive characteristics of the population, as well as in its research question and analytical approach, by examining whether sex moderates the association between CMJ performance and sprint speed during adolescence. Recent studies, such as those by He et al. [6] and Pamuk et al. [7], indicate that variables stemming from CMJ, such as height and relative power (as manifested in force production during dynamic movements), can explain a considerable proportion of the variability in sprint performance. Likewise, research efforts with young athletes have demonstrated significant associations between CMJ—including unilateral variations—and the 20 m sprint, as well as with agility tests, reinforcing the idea that the vertical jump efficiently captures the lower-body explosive capacity in populations at the sports training stage [1,7]. In addition, body fat percentage, along with neuromuscular capabilities, and anthropometric and body composition factors, significantly influence sprint performance during adolescence [8,9]; higher body fat has been associated with slower times in speed tests and lower performance in explosive movements, likely due to the increased non-functional body mass that must be accelerated when running [10,11]. These dynamics are particularly relevant during adolescence, when biological maturation and peak height velocity are accompanied by sex-specific changes in muscle mass, relative strength, and body fat distribution [2,3]. In has been shown that performance differences between males and females in sprinting, jumping, and relative strength widen between the ages of 14 and 16, coinciding with the period of greatest gains in anaerobic capacity and force production in males [12,13].

Biological maturation and sex jointly modulate the relationship between muscle power and speed performance [14,15]. Recent studies in young athletes have shown that males past their peak height velocity reach higher CMJ values and better sprint times compared to females of similar chronological age, which is attributed to differences in muscle mass, relative strength, and neuromuscular activation patterns [3,6]. However, despite the strong evidence linking CMJ to sprinting, most studies have either focused on predominantly male samples or have considered sex solely as a descriptive covariate, without delving into the potential interaction between CMJ performance and sex in predicting sprint speed during adolescence [5,6]. In the Latin American and Chilean context, a link has been described between body composition, vertical jump, and sprinting in children and adolescents, as well as anthropometric and physical fitness reference tables that demonstrate the impact of body mass and physical condition on physical performance [9,16]. However, evidence that simultaneously integrates neuromuscular and anthropometric variables into explanatory models of speed performance in adolescent athletes of both sexes involved in different sports remains limited. Given that adolescence is a critical stage for the development of power and speed, and that performance differences between males and females can consolidate or widen during this period [2,3], it is necessary to further investigate how CMJ performance relates to sprint speed and to what extent this relationship is modulated by anthropometric variables and sex. Therefore, the objective of this study was to examine the relationship between countermovement jump (CMJ) performance and sprint speed in adolescent athletes, considering the influence of anthropometric variables, and to determine whether this relationship differs between males and females.

2. Materials and Methods

2.1. Design

A cross-sectional observational study was conducted to examine the association between countermovement jump (CMJ) performance an 20 m sprint time in adolescent athletes, considering anthropometric variables and evaluating whether this association differed by sex through prespecified sex-stratified analyses.

2.2. Participants

The sample was selected using non-probabilistic convenience sampling and consisted of 140 adolescent athletes (43 females, 97 males aged 14 to 17) from the Promesas Ñuble program in Chillán, Ñuble Region (Chile). Participants represented different sports disciplines. Among male athletes (n = 97), 17 participated in volleyball, 6 in swimming, 11 in rugby, 21 in handball, 23 in table tennis, and 19 in basketball. Among female athletes (n = 43), 12 participated in volleyball, 10 in handball, 9 in table tennis, 3 in swimming, and 9 in basketball. Inclusion criteria were: (1) being aged between 14 and 17 years at the time of assessment; (2) being officially enrolled in a sports club in the region; (3) being selected for the Promesas Deportivas Ñuble program; and (4) providing informed assent and written parental or legal guardian consent. Exclusion criteria were: (1) failure to complete all physical assessments; and (2) any injury or illness reported by the participant or coach that could interfere with the assessments.

2.3. Procedure

Authorization was granted by the National Sports Institute (IND) of Ñuble and the participating clubs, detailing the study's objectives, procedures, and scope. All participants and guardians signed informed consent forms in accordance with the Declaration of Helsinki [17]. The protocol was approved by the Ethics Scientific Committee of the Adventist University of Chile (No. 2025-026).

The evaluations were conducted between August and October 2025 at gyms in Chillán where the athletes train regularly (3 weekly sessions of ~1.5 h, except on weekends). A team of six evaluators trained in assessing young athletes employed a standardized protocol: a 15 min warm-up (multidirectional movements, jumps, accelerations/decelerations, dynamic flexibility), followed by tests in sequential order: body composition (weight, height, body fat %), flexibility (Wells-Dillon), vertical jumps (SJ, CMJ, ABK), and sprints (10–20 m). Each test was performed twice, and the best attempt was registered for analysis.

2.4. Protocols and Instruments

2.4.1. Body Composition Measurements

Height (cm) was measured barefoot in the Frankfort horizontal plane using a stadiometer calibrated in millimeters (Seca, 213 portable stadiometer, Seca GmbH & Co. KG, Hamburg, Germany). Body weight, body mass index (BMI), and body fat percentage will be determined using a digital bioimpedance scale with an accuracy of 100 g (OMRON HBF-514C, OMRON Healthcare, Kyoto, Japan).

2.4.2. Biological Maturation

Biological maturation was estimated using the sex-specific maturity offset equations proposed by Moore et al. [18]. Maturity offset, expressed as the estimated number of years before or after peak height velocity (PHV), was calculated from chronological age and stature using the following equations:

$$\text{Males: Maturity offset (years)} = -7.999994 + [0.0036124 \times (\text{age} \times \text{stature})].$$

$$\text{Females: Maturity offset (years)} = -7.709133 + [0.0042232 \times (\text{age} \times \text{stature})].$$

Negative values indicate years before PHV, whereas positive values indicate years after PHV. Participants were subsequently categorized according to their proximity to PHV as pre-PHV (<−1 year), circa-PHV (−1 to +1 year), or post-PHV (>+1 year).

$$\text{Males; APVC} = -7.999994 + [0.0036124 \times (\text{age} \times \text{size})].$$

$$\text{Females; APVC} = -7.709133 + [0.0042232 \times (\text{age} \times \text{size})].$$

2.4.3. Cardiorespiratory Endurance Test

The 20 m Shuttle Run Test Léger et al. [19] was administered on a flat, firm, non-slip surface, with two parallel lines marked 20 m apart. Participants ran back and forth between the lines following a pre-recorded audio pace (starting at 8.5 km·h^{-1}, with increments of 0.5 km·h^{-1} per minute/stage), touching the line with at least one foot before each acoustic signal and reversing direction. The test ended after two consecutive failures to reach the line or intentional withdrawal due to fatigue, with the last completed level/stage registered. Materials: track cones, measuring tape, audio player with standardized recording, amplifier, and data sheets. VO_2max (ml·kg^{-1}·min^{-1}) was estimated using:

$$VO_2\text{max (ml·kg}^{-1}\text{·min}^{-1}) = 31.025 + (3.238 \times V) - (3.248 \times \text{Age}) + (0.1536 \times V \times \text{Age}),$$

where V = final velocity (km·h^{-1}) and Age = participant's age (in years).

2.4.4. Flexibility Test

The Wells and Dillon flexibility test was administered using a standardized box (30 × 30 × 30 cm) with a graduated ruler on top (0 cm aligned with the edge where the feet rest; the positive scale extends away from the participant, and the negative scale toward them).

From a seated position with feet perpendicular to the platform, the participants performed a progressive forward trunk flexion with their hands sliding along the ruler (without bending the knees, bouncing, or performing ballistic movements), holding the maximum position for 2 s and recording the value (in centimeters) reached by the fingertips.

2.4.5. Jumping Test

Vertical jumps were performed according to the protocol of Bosco [20], with maximum height logged using the Optojump Next optical system (Microgate, Bolzano, Italy) based on flight time. Each jump was performed twice, and the best valid attempt was logged.

Countermovement jump (CMJ): From an upright position (feet shoulder-width apart, hands on hips), simultaneous and controlled hip–knee flexion (~90°), followed by explosive hip–knee–ankle extension to reach maximum vertical height. Simultaneous takeoff and landing without horizontal displacement.

Squat jump (SJ): Standing position (feet shoulder-width apart, hands on hips), controlled descent to ~90°, knee flexion (upright torso, heels on the ground), 2–3 s pause (eliminating the stretch-shortening cycle), maximum explosive extension without countermovement or arm momentum.

Abalakov jump (ABK): Upright position, rapid knee flexion (~90° or free angle) with arms swinging backward, maximum vertical jump by driving arms upward. Landing with knees extended for precise measurement on the platform.

2.4.6. 10 and 20 m Sprint Test

The 10 and 20 m sprint test was conducted on a flat, non-slip surface, using photocell-based electronic timing (Witty, Microgate®, Bolzano, Italy) positioned at 10 and 20 m from the starting line, at a height of 1.0 m. Participants started from a static free-start position (front foot behind the line to prevent false starts), accelerating at maximum intensity at the evaluator's signal until reaching 20 m. Two attempts were made with a 2 to 3 min recovery period between them, and the best valid time was registered.

2.5. Statistical Analysis

All statistical analyses were performed using R software (version 2026.08.2) within the RStudio environment. Descriptive statistics were calculated first; continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies (n, %). Sample characteristics were described for the total population and stratified by sex. Between-sex differences in continuous variables were assessed using independent-samples Student's *t*-tests, with Cohen's *d* calculated as the corresponding effect size. Differences in the distribution of maturation status (pre-PHV, circa-PHV, and post-PHV) between sexes were assessed using Pearson's chi-square test, with Cramér's *V* calculated as the corresponding effect size. Associations between performance variables were analyzed using Pearson correlations, including the 20 m sprint, SJ, CMJ, ABK, body fat percentage, height, and age. To account for multiple testing across the pairwise correlations, *p*-values were adjusted using the Benjamini–Hochberg false discovery rate (FDR) procedure. To examine factors associated with sprint performance, multiple linear regression models were estimated with 20 m sprint time as the dependent variable. Due to the very high correlations observed among vertical jump measures (CMJ–SJ: $r = 0.953$; CMJ–ABK: $r = 0.952$), only CMJ was included as an indicator of neuromuscular performance in the multiple regression models to minimize redundancy and potential multicollinearity among predictors. The main model included CMJ, body fat percentage, height, age, and sex as predictors. Results were reported using unstandardized regression coefficients (B), standard errors (SE), 95% confidence intervals (95% CI), *t*-values, *p*-values, and standardized coefficients (β),

along with R^2 and adjusted R^2. To assess whether the association between CMJ and 20 m sprint time differed by sex, a CMJ × sex interaction term was included. Sex-stratified models were subsequently estimated to characterize the association within each subgroup. Given the smaller female subgroup, confidence intervals were emphasized to assess the precision and uncertainty of the sex-specific estimates. Finally, regression assumptions, including normality of residuals, homoscedasticity, and multicollinearity, were assessed using diagnostic plots and variance inflation factors (VIFs). Statistical significance was set at $p < 0.05$.

Potentially influential observations were assessed using Cook's distance, with values exceeding 4/n used as an exploratory criterion for further examination. When an influential observation was identified, sensitivity analyses were performed by refitting the corresponding regression models after excluding that observation. Observations were not excluded from the primary analyses solely on the basis of influence diagnostics; their validity was verified against the original records.

3. Results

The sample consisted of 140 adolescent participants whose descriptive characteristics are presented in Table 1. In general, males exhibited higher values for neuromuscular performance variables, including squat jump (SJ), countermovement jump (CMJ), and Abalakov jump (ABK), as well as faster sprint times over the 10 m and 20 m distances, compared to females. Likewise, differences between sexes were observed in anthropometric and body composition variables, particularly in body mass, height, and body fat percentage. Regarding biological maturation status, most participants were in the post-PHV category, followed by the circa-PHV category, and a smaller number of subjects in the pre-PHV stage.

Table 1. Descriptive characteristics of the total sample stratified by sex.

Variable	Total (n = 140)	Female (n = 43)	Male (n = 97)	*p*-Value	Effect Size
Age (years)	15.60 ± 1.92	15.58 ± 1.84	15.62 ± 1.96	0.913	−0.02
Body mass (kg)	67.25 ± 14.93	58.46 ± 10.45	71.14 ± 15.01	<0.001	−0.92
Height (cm)	165.45 ± 10.53	158.21 ± 6.71	168.66 ± 10.34	<0.001	−1.11
BMI ($kg \cdot m^{-2}$)	24.35 ± 4.27	23.12 ± 3.67	24.90 ± 4.42	0.023	−0.42
Body fat (%)	24.35 ± 9.40	30.21 ± 8.76	21.75 ± 8.49	<0.001	0.99
Flexibility (cm)	10.43 ± 6.60	12.96 ± 5.82	9.31 ± 6.64	0.002	0.57
SJ (cm)	24.98 ± 7.04	21.03 ± 4.00	26.74 ± 7.39	<0.001	−0.87
CMJ (cm)	26.33 ± 7.49	22.04 ± 4.20	28.24 ± 7.85	<0.001	−0.89
ABK (cm)	30.84 ± 9.03	25.32 ± 4.79	33.28 ± 9.40	<0.001	−0.96
20 m sprint (s)	3.74 ± 0.39	3.98 ± 0.32	3.64 ± 0.37	<0.001	0.95
VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	39.52 ± 6.61	33.34 ± 3.51	42.25 ± 5.77	<0.001	−1.72
Maturation status				0.109	0.18
Pre-PHV	9 (6.4%)	3 (7.0%)	6 (6.2%)		
Circa-PHV	45 (32.1%)	19 (44.2%)	26 (26.8%)		
Post-PHV	86 (61.4%)	21 (48.8%)	65 (67.0%)		

Note: Values are presented as mean ± SD for continuous variables and n (%) for categorical variables. Differences between females and males in continuous variables were assessed using independent-samples Student's *t*-tests, with Cohen's d reported as the corresponding effect size. Maturation status was compared using the chi-square test, with Cramér's V reported as the effect size. SJ: squat jump; CMJ: countermovement jump; ABK: Abalakov jump; BMI: body mass index; PHV: peak height velocity; VO_2max: estimated maximum oxygen consumption.

Additional analyses were conducted to evaluate the influence of biological maturation on sprint performance. Chronological age and maturation status were strongly associated (Spearman's $\rho = 0.808$, $p < 0.001$), indicating substantial overlap between these variables.

Nevertheless, maturation status was initially evaluated alongside chronological age to determine whether it provided additional explanatory information beyond chronological age and the other anthropometric and neuromuscular variables included in the model. Specifically, maturation status was included as a predictor in multiple linear regression models along with CMJ, body fat percentage, height, and age. Results showed that maturation status was not significantly associated with 20 m sprint time ($B = -0.081$, $p = 0.311$), and its inclusion did not improve model fit ($R^2 = 0.604$; adjusted $R^2 = 0.589$) compared with models that did not include this variable. Similarly, maturation status remained non-significant ($p = 0.311$) in the model including the CMJ × sex interaction, whereas the CMJ × sex interaction remained significant ($p = 0.035$). These findings indicate that maturation status did not provide additional explanatory information beyond the neuromuscular and anthropometric variables already considered. Therefore, to maintain model parsimony and interpretability, maturation status was not retained in the final models, although it is reported descriptively. Importantly, the absence of an independent contribution of maturation status in the present models should not be interpreted as evidence that biological maturation is irrelevant to sprint performance. The strong association between chronological age and maturation status, together with the predominance of post-PHV participants in the sample, may have limited the unique information provided by maturation status after accounting for age and the other variables included in the model. Moreover, maturation-related differences in sprint performance may be partly reflected in anthropometric and neuromuscular characteristics already represented in the model, such as CMJ performance, body fat percentage, and height.

The associations among the performance variables are presented in Table 2. A strong negative correlation was observed between CMJ and the 20 m sprint time ($r \approx -0.76$), indicating that greater jump heights were associated with faster sprint times. Consistently, the SJ and ABK vertical jump variables also showed negative correlations with the 20 m sprint, suggesting that vertical jump performance is closely related to the running speed capacity. On the other hand, body fat percentage showed positive correlations with sprint time, indicating that higher levels of body fat were associated with poorer running performance. The relationship between CMJ performance and the 20 m sprint in the total sample is presented in Figure 1, which shows a consistent negative association between both variables.

Table 2. Pearson correlation matrix among sprint, jump, anthropometric, and age variables.

Variable	Sprint 20 m (s)	Sprint 10 m (s)	SJ (cm)	CMJ (cm)	ABK (cm)	Body Fat (%)	Height (cm)	Age (years)
Sprint 20 m (s)	1	0.857 ***	−0.727 ***	−0.756 ***	−0.730 ***	0.412 ***	−0.531 ***	−0.435 ***
Sprint 10 m (s)	0.857 ***	1	−0.595 ***	−0.613 ***	−0.597 ***	0.382 ***	−0.426 ***	−0.337 ***
SJ (cm)	−0.727 ***	−0.595 ***	1	0.953 ***	0.925 ***	−0.490 ***	0.486 ***	0.430 ***
CMJ (cm)	−0.756 ***	−0.613 ***	0.953 ***	1	0.952 ***	−0.464 ***	0.558 ***	0.471 ***
ABK (cm)	−0.730 ***	−0.597 ***	0.925 ***	0.952 ***	1	−0.444 ***	0.541 ***	0.449 ***
Body fat (%)	0.412 ***	0.382 ***	−0.490 ***	−0.464 ***	−0.444 ***	1	−0.233 **	0.010
Height (cm)	−0.531 ***	−0.426 ***	0.486 ***	0.558 ***	0.541 ***	−0.233 **	1	0.448 ***
Age (years)	−0.435 ***	−0.337 ***	0.430 ***	0.471 ***	0.449 ***	0.010	0.448 ***	1

Values are Pearson correlation coefficients (r). *p*-values were adjusted using the Benjamini–Hochberg false discovery rate procedure across the 28 pairwise correlations. ** $p < 0.01$; *** $p < 0.001$. SJ = squat jump; CMJ = countermovement jump; ABK = Abalakov jump.

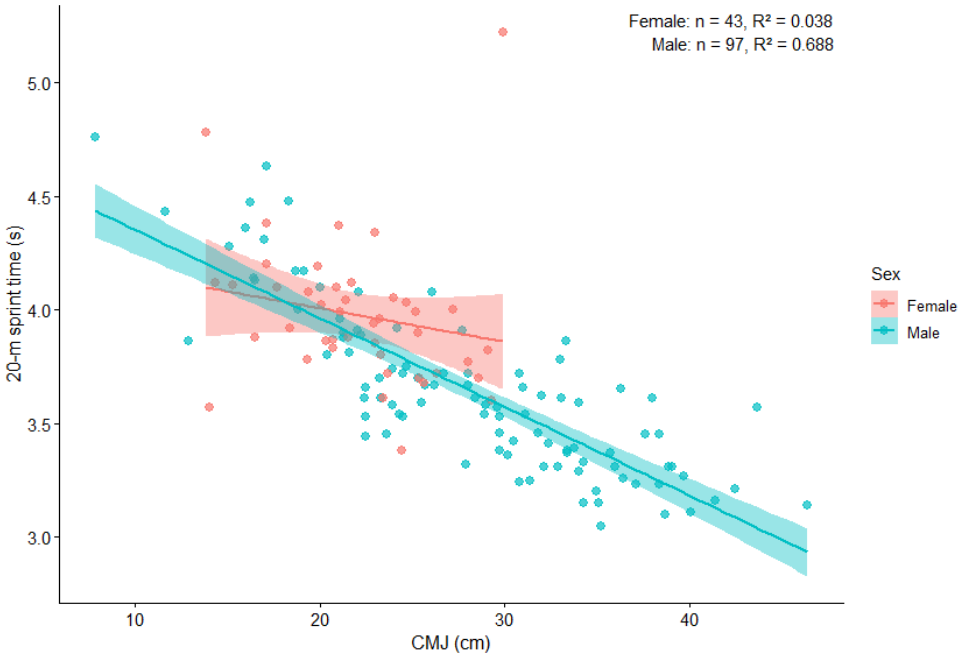

Figure 1. Relationship between countermovement jump (CMJ) height and 20 m sprint time by sex. Each point represents an individual participant, and the lines represent sex-specific unadjusted linear regression fits with 95% confidence intervals. The female subgroup comprised n = 43 participants (R^2 = 0.038), whereas the male subgroup comprised n = 97 (R^2 = 0.688). The observed CMJ ranges were 13.8–29.9 cm in females and 7.8–46.4 cm in males. Therefore, visual comparisons between sex-specific regression lines should be interpreted with consideration of the different predictor ranges and the limited overlap at the extremes.

A multiple linear regression model was estimated to identify the factors associated with sprint performance; the results are presented in Table 3. The model showed moderate explanatory power for the 20 m sprint, with an R^2 of 0.608 and an adjusted R^2 of 0.594. No evidence of problematic multicollinearity was observed in the final regression model. VIF values were 2.10 for CMJ, 1.49 for body fat percentage, 1.85 for height, 1.60 for age, and 1.55 for sex. Among the included predictors, CMJ stood out as the strongest predictor of sprint performance, exhibiting a significant negative coefficient, which indicates that greater jump heights were associated with shorter sprint times. Body fat percentage showed a positive bivariate correlation with 20 m sprint time (r = 0.412), indicating that higher body fat was associated with slower sprint performance at the correlational level. However, body fat percentage was not independently associated with sprint time in the multivariable regression model (B = 0.004, 95% CI [−0.002, 0.009], p = 0.196).

Table 3. Multiple linear regression model predicting 20 m sprint time in the total sample.

Predictor	B	SE	95% CI	t	*p*	β
Intercept	5.4219	0.3757	[4.6787, 6.1650]	14.430	<0.001	—
CMJ (cm)	−0.0290	0.0040	[−0.0370, −0.0210]	−7.199	<0.001	−0.564
Body fat (%)	0.0035	0.0027	[−0.0018, 0.0089]	1.299	0.196	0.086
Height (cm)	−0.0032	0.0027	[−0.0085, 0.0021]	−1.196	0.234	−0.088
Age (years)	−0.0260	0.0137	[−0.0531, 0.0012]	−1.890	0.061	−0.129
Sex (Male)	−0.0907	0.0560	[−0.2014, 0.0201]	−1.619	0.108	−0.109

Note. B = unstandardized regression coefficient; SE = standard error; 95% CI = 95% confidence interval; β = standardized regression coefficient; CMJ = countermovement jump. Female was the reference category for sex. Model fit: R^2 = 0.608; adjusted R^2 = 0.594.

An additional model including a CMJ × sex interaction term was estimated to determine whether the association between CMJ performance and 20 m sprint time differed by sex (Table 4). In the primary analysis, the CMJ × sex interaction was statistically significant (B = −0.0217 s·cm^{-1}, 95% CI [−0.0414, −0.0019], $p = 0.032$), indicating a statistically significant difference in the slope relating CMJ to sprint time between females and males. With females as the reference category, the estimated CMJ slope in females was −0.0107 s·cm^{-1} (95% CI [−0.0291, 0.0078], $p = 0.256$), whereas the interaction coefficient indicated a more negative slope in males. Sex-stratified models were subsequently examined to characterize these associations within each subgroup. However, as described in the sensitivity analysis below, the CMJ × sex interaction was not robust to the exclusion of a valid influential observation in the female subgroup. Therefore, the evidence for sex-specific differences in the CMJ–sprint association should be interpreted cautiously.

Table 4. Multiple linear regression model including the CMJ × sex interaction for 20 m sprint time.

Predictor	B	SE	95% CI	t	*p*	β
Intercept	4.9982	0.4190	[4.1695, 5.8269]	11.930	<0.001	—
CMJ (cm)	−0.0107	0.0093	[−0.0291, 0.0078]	−1.141	0.256	−0.500
Sex (Male)	0.4154	0.2398	[−0.0589, 0.8898]	1.732	0.086	−0.187
Body fat (%)	0.0034	0.0027	[−0.0019, 0.0087]	1.284	0.201	0.084
Height (cm)	−0.0041	0.0027	[−0.0094, 0.0012]	−1.517	0.132	−0.111
Age (years)	−0.0159	0.0143	[−0.0442, 0.0125]	−1.108	0.270	−0.079
CMJ × Sex	−0.0217	0.0100	[−0.0414, −0.0019]	−2.169	0.032	−0.195

Note. B = unstandardized regression coefficient; SE = standard error; 95% CI = 95% confidence interval; β = standardized regression coefficient; CMJ = countermovement jump. Female was the reference category for sex. Model fit: $R^2 = 0.622$; adjusted $R^2 = 0.605$; $F(6, 133) = 36.43$, $p < 0.001$.

The 20 m sprint time was used as the dependent variable, while CMJ, body fat percentage, height, age, and sex were included as predictors. The CMJ × sex interaction term was included to assess whether the relationship between jump performance and sprint speed differed between men and women. The results are presented as unstandardized coefficients (B), standard errors (SE), t-values, *p*-values, and standardized coefficients (β). Sex was coded using "female" as the reference category; therefore, the Sex (Male) coefficient represents the difference between men and women. A significant interaction term indicates that the slope of the relationship between CMJ and sprint time differs according to sex.

Because a significant CMJ × sex interaction was identified, regression models stratified by sex were subsequently estimated (Table 5). In males (n = 97), the model explained a substantial proportion of the variance in 20 m sprint time ($R^2 = 0.746$; adjusted $R^2 = 0.735$), and CMJ showed a significant negative association with sprint time (B = −0.0267 s·cm^{-1}, 95% CI [−0.0343, −0.0190], $p < 0.001$). In females (n = 43), the model explained considerably less variance ($R^2 = 0.082$; adjusted $R^2 = -0.015$), and the overall model was not statistically significant, $F(4, 38) = 0.850$, $p = 0.503$. Although the estimated CMJ coefficient was negative (B = −0.0240 s·cm^{-1}), its 95% confidence interval was relatively wide and included zero (95% CI [−0.0542, 0.0062], $p = 0.116$), indicating substantial uncertainty regarding the magnitude of the association in the female subgroup. Accordingly, the absence of statistical significance in females should not be interpreted as evidence of the absence of an association. Differences in the distribution of sprint times between men and women are shown in Figure 2.

Table 5. Sex-stratified multiple linear regression models predicting 20 m sprint time.

Group	Predictor	B	SE	95% CI	t	*p*	β
Female	Intercept	2.6991	1.2232	[0.2228, 5.1753]	2.207	0.033	—
Female	CMJ (cm)	−0.0240	0.0149	[−0.0542, 0.0062]	−1.610	0.116	−0.317
Female	Body fat (%)	0.0007	0.0060	[−0.0114, 0.0127]	0.112	0.912	0.018
Female	Height (cm)	0.0124	0.0097	[−0.0072, 0.0319]	1.278	0.209	0.261
Female	Age (years)	−0.0108	0.0316	[−0.0747, 0.0531]	−0.343	0.734	−0.063
Male	Intercept	5.9067	0.3314	[5.2485, 6.5650]	17.822	<0.001	—
Male	CMJ (cm)	−0.0267	0.0038	[−0.0343, −0.0190]	−6.939	<0.001	−0.569
Male	Body fat (%)	0.0056	0.0026	[0.0004, 0.0108]	2.144	0.035	0.130
Male	Height (cm)	−0.0064	0.0023	[−0.0109, −0.0019]	−2.827	0.006	−0.179
Male	Age (years)	−0.0357	0.0147	[−0.0649, −0.0066]	−2.434	0.017	−0.190

Note. The female subgroup comprised n = 43 participants and the male subgroup n = 97. Given the smaller female subgroup, estimates from the female model should be interpreted with particular consideration of their 95% confidence intervals. B = unstandardized regression coefficient; SE = standard error; 95% CI = 95% confidence interval; β = standardized regression coefficient; CMJ = countermovement jump. Female model: n = 43, R^2 = 0.082, adjusted R^2 = −0.015, F(4, 38) = 0.850, p = 0.503. Male model: n = 97, R^2 = 0.746, adjusted R^2 = 0.735, F(4, 92) = 67.66, $p < 0.001$.

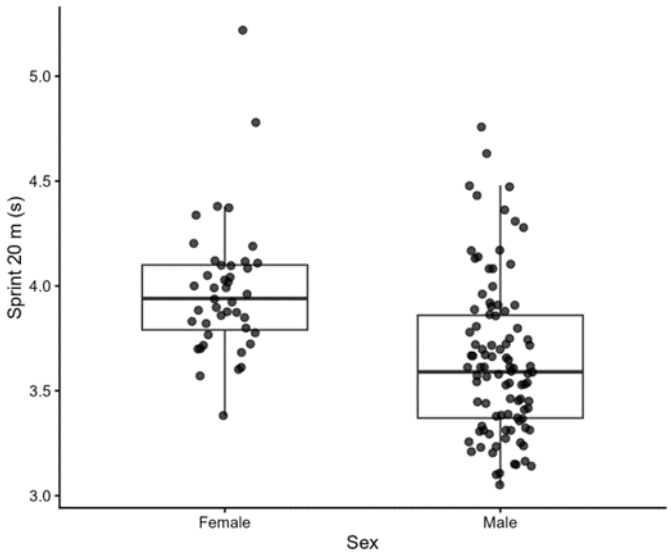

Figure 2. Time distribution in the 20 m sprint according to sex. The box plots show the median, interquartile range, and outliers for men and women, whereas the points represent individual observations.

Influence diagnostics identified three observations in the female subgroup exceeding the exploratory Cook's distance criterion of 4/n (D = 0.342, 0.193, and 1.238). The observation with the greatest influence corresponded to a female participant with a 20 m sprint time of 5.22 s and a CMJ height of 29.9 cm (Cook's D = 1.238). Verification against the original records confirmed that these values represented valid measurements; therefore, the participant was retained in the primary analyses. Sensitivity analyses excluding this observation substantially altered the female-specific results. In the female multivariable model, the CMJ coefficient changed from B = −0.0240 (95% CI [−0.0542, 0.0062], p = 0.116) to B = −0.0358 (95% CI [−0.0580, −0.0136], p = 0.002), with model fit increasing from R^2 = 0.082 to R^2 = 0.256. Importantly, the CMJ × sex interaction changed from B = −0.0217 (95% CI [−0.0414, −0.0019], p = 0.032) in the primary analysis to B = −0.0051 (95% CI [−0.0226, 0.0125], p = 0.568) in the sensitivity analysis. Thus, although the interaction was

statistically significant in the complete sample, evidence for sex-specific differences in the CMJ–sprint association was sensitive to this influential observation.

Finally, standardized regression coefficients and their 95% confidence intervals are presented in Figure 3. CMJ showed the largest standardized coefficient in absolute magnitude ($\beta = -0.564$) and was the only predictor with a 95% confidence interval that did not include zero. The remaining predictors showed substantially smaller standardized coefficients and greater uncertainty.

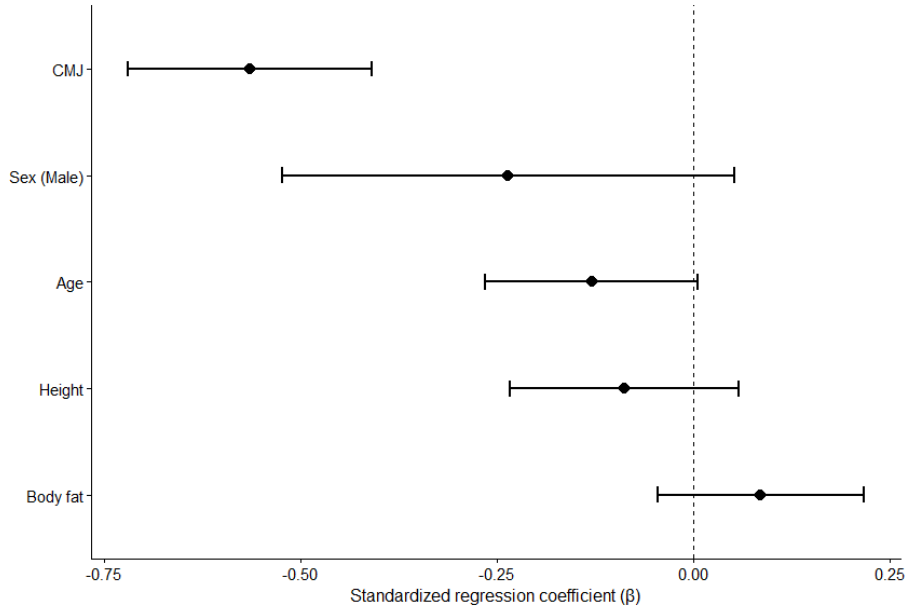

Figure 3. Standardized regression coefficients for predictors of 20 m sprint time. Points represent standardized regression coefficients (β), and horizontal error bars represent 95% confidence intervals. The vertical dashed line indicates $\beta = 0$. CMJ = countermovement jump.

Overall, CMJ performance was strongly associated with sprint performance in adolescent athletes. Although the primary analysis identified a significant CMJ × sex interaction, sensitivity analysis indicated that this result was substantially influenced by one valid influential observation in the female subgroup. Therefore, the evidence for sex-specific differences in the CMJ–sprint association should be interpreted cautiously.

4. Discussion

The objective of this study was to examine the relationship between countermovement jump (CMJ) performance and sprint speed in adolescent athletes, considering the influence of anthropometric variables, and to determine whether this relationship differed between males and females. The main findings indicated that CMJ performance was strongly and negatively correlated with 20 m sprint time ($r \approx -0.76$), indicating that greater jump heights were associated with faster sprint times. Furthermore, in the multiple linear regression analysis, CMJ emerged as the strongest predictor of sprint performance in the total sample, with the overall model explaining approximately 61% of the variance in 20 m sprint time ($R^2 = 0.608$; adjusted $R^2 = 0.594$). In the primary analysis, a significant CMJ × sex interaction was observed ($B = -0.0217$ s·cm^{-1}, 95% CI [−0.0414, −0.0019], $p = 0.032$), suggesting that the association between CMJ performance and sprint time differed by sex. Sex-stratified analyses showed a clear negative association between CMJ and sprint time in males ($B = -0.0267$ s·cm^{-1}, 95% CI [−0.0343, −0.0190], $p < 0.001$), whereas the corresponding estimate in females was less precise and its confidence interval included zero ($B = -0.0240$ s·cm^{-1}, 95% CI [−0.0542, 0.0062], $p = 0.116$). However, influence diagnostics identified one

valid but highly influential observation in the female subgroup (Cook's D = 1.238). When this observation was excluded in a sensitivity analysis, the female-specific CMJ coefficient became more negative and statistically significant (B = −0.0358 s·cm^{-1}, 95% CI [−0.0580, −0.0136], $p = 0.002$), while the CMJ × sex interaction was substantially attenuated and no longer statistically significant (B = −0.0051 s·cm^{-1}, 95% CI [−0.0226, 0.0125], $p = 0.568$). Because verification of the original records confirmed that this observation represented a valid measurement, the participant was retained in the primary analyses. Nevertheless, the sensitivity analysis indicates that the evidence for sex-specific differences in the CMJ–sprint association is not robust to the influence of this observation. Therefore, the apparent sex-related difference observed in the primary analysis should be interpreted cautiously rather than as definitive evidence of sex moderation.

Regarding biological maturation, chronological age and maturation status were strongly associated (Spearman's ρ = 0.808, $p < 0.001$), indicating substantial overlap between these variables. Maturation status did not provide additional explanatory information after accounting for chronological age and the other variables included in the model (B = −0.081, $p = 0.311$) and was therefore not retained in the final regression models. Accordingly, the present data do not support interpreting maturation status as an independent predictor of sprint performance in this sample. Biological mechanisms associated with pubertal development, including sex-related differences in hormonal profiles, body composition, and neuromuscular development, may contribute to differences in jumping and sprinting performance [12,13,21]. However, these mechanisms were not directly measured in the present study and should therefore be regarded as biologically plausible hypotheses rather than mechanisms demonstrated by the current analyses.

The strong association observed between CMJ and sprint speed is consistent with recent literature underscoring the role of lower-body power as a key determinant of performance in explosive movements. Several studies have shown that performance on vertical jump tests is closely related to acceleration capacity and maximum speed in young athletes, since both abilities depend largely on the production of strength and power during muscle stretch-shortening cycles [1,22]. In this sense, CMJ is considered a valid indicator of neuromuscular performance and a useful predictor of sprint performance in university athletes [23,24]. Recent findings in young Chilean athletes that have shown significant relationships between lower-body power tests and performance in short, high-intensity sprints [25], as well as in young Chilean soccer players, where CMJ has been consistently associated with performance in 10–30 m sprints and agility tests, reinforce its usefulness as an indicator of explosive performance in this population [26].

Moreover, body fat percentage was positively correlated with sprint time in the bivariate analysis, indicating that greater adiposity was associated with slower sprint performance. However, this association was attenuated and was no longer statistically significant after adjustment for CMJ, height, age, and sex in the multivariable model. Nevertheless, the direction of the observed association is consistent with previous research suggesting that greater adiposity may negatively influence performance in explosive locomotor tasks by increasing the non-functional body mass that must be accelerated during running [27,28]. Similar findings have been reported in young Chilean tennis players, in whom higher body fat percentage and greater skinfold thickness were associated with slower 5 m sprint times [25]. In young athletes, body composition may influence the relationship between neuromuscular capabilities and physical performance, particularly during the initial acceleration phase [29]. This relationship has also been examined in Chilean school populations, where anthropometric and physical fitness reference charts have highlighted associations between body composition and physical performance [16], and adequate adiposity levels have been associated with better performance in speed, agility, and jumping tasks [9]. Taken together,

these findings support the potential relevance of body composition to sprint performance during adolescence; however, in the present study, body fat percentage did not explain additional variance in 20 m sprint time after accounting for CMJ, height, age, and sex.

Another relevant finding was the statistically significant interaction between CMJ and sex observed in the primary analysis, suggesting that the association between CMJ performance and sprint time differed between males and females. In particular, males achieved greater heights in CMJ and SJ and faster times in the 10 m and 20 m sprints. These sex-related differences in physical performance may become more pronounced during adolescence as a consequence of sex-specific maturational changes, including increases in testosterone in males that contribute to greater muscle mass and anaerobic power [30]. However, this interpretation should be considered a biologically plausible explanation derived from previous research rather than a direct finding of the present study, because maturation status was not significantly associated with 20 m sprint time in the preliminary analysis ($B = -0.081$, $p = 0.311$) and was therefore not retained in the final regression models. As most participants in the present sample were in the post-PHV stage, this classification provides descriptive context regarding the maturational characteristics of the sample but does not demonstrate that post-PHV status caused or independently explained the observed sex-related differences. Nevertheless, biological and neuromuscular factors associated with pubertal development may partly contribute to differences in physical performance, although these mechanisms were not directly measured in the present study. During this phase, males typically experience more pronounced increases in explosive strength and neuromuscular development, which may favor both vertical jumping and sprint performance [2,12,31]. Accordingly, the cited literature can support the plausibility of a maturational contribution, but the present results do not establish maturation as an independent predictor of sprint performance. Likewise, previous research suggests that sex-related differences in the association between muscle power and sprint performance may involve technical, neuromuscular, and motor coordination factors, with greater hip extensor muscle volume potentially contributing to enhanced horizontal propulsion and faster sprint performance [32]. Sprint performance in adolescent females may also be influenced by biomechanical variables, stride characteristics, and mechanical efficiency [33,34]. The possibility that CMJ and sprint performance may respond independently is also supported by intervention-based evidence. Galiano et al. [35] reported similar improvements in CMJ performance in male and female athletes following six weeks of accentuated eccentric resistance training, whereas sprint and change-of-direction performance remained unchanged in both groups. These findings indicate that improvements in vertical jump performance do not necessarily translate into improvements in sprint performance, regardless of sex, and therefore provide relevant context for interpreting the present cross-sectional associations.

In the primary sex-stratified analyses, the association between CMJ performance and sprint performance was less precise in females than in males. Although the estimated CMJ coefficient in females was negative ($B = -0.0240$ s·cm^{-1}), its relatively wide 95% confidence interval (-0.0542 to 0.0062) included zero ($p = 0.116$), indicating substantial uncertainty regarding the magnitude of this association. Therefore, the female-specific estimate in the primary analysis should be regarded as imprecise rather than as evidence of a null relationship. Importantly, influence diagnostics identified one valid but highly influential observation in the female subgroup (Cook's $D = 1.238$). Sensitivity analysis excluding this observation substantially altered the female-specific estimate, with the CMJ coefficient becoming more negative and statistically significant ($B = -0.0358$ s·cm^{-1}, 95% CI $[-0.0580, -0.0136]$, $p = 0.002$). More importantly, the CMJ × sex interaction observed in the primary analysis was substantially attenuated and was no longer statistically significant after exclusion of this observation ($B = -0.0051$ s·cm^{-1}, 95% CI $[-0.0226, 0.0125]$, $p = 0.568$).

Verification against the original records confirmed that this observation represented a valid measurement; therefore, there was no methodological justification for excluding the participant from the primary analyses. Nevertheless, the sensitivity analysis demonstrates that both the female-specific estimate and the evidence for sex-related differences were strongly influenced by this observation. The smaller female sample (n = 43), together with potential heterogeneity in age, maturation status, and sporting background, may have further contributed to the uncertainty of the female-specific estimate. However, because maturation status was not significantly associated with 20 m sprint time in the present sample, its contribution to this uncertainty remains unclear and should not be considered a confirmed explanation. Consequently, the statistically significant CMJ × sex interaction observed in the primary analysis should not be interpreted as robust evidence that sex moderates the CMJ–sprint relationship. Rather, the present findings support a strong overall association between CMJ and sprint performance, while the extent to which this relationship differs between male and female adolescent athletes remains uncertain. Future studies should examine whether sex and maturation status modify the CMJ–sprint association using larger and more balanced samples and adequately powered formal interaction analyses rather than relying solely on post-PHV classification.

From an applied perspective, the results of this study support the usefulness of the CMJ as a simple and practical tool for monitoring neuromuscular performance related to sprint ability in adolescent athletes. However, although a significant CMJ × sex interaction was observed in the primary analysis, the sensitivity analysis showed that this interaction was substantially influenced by one valid influential observation in the female subgroup and was no longer statistically significant when that observation was excluded. Therefore, the present findings do not provide sufficiently robust evidence to support sex-specific interpretations of the CMJ–sprint relationship in practice. The use of vertical jump tests allows for a rapid assessment of explosive strength production capacity, which is relevant for monitoring physical development and planning training in sports that require acceleration and speed [1,24]. This is consistent with studies demonstrating the high reliability and practical utility of field-test batteries for evaluating physical fitness and performance in young Chilean athletes [16,36]. Given the uncertainty and sensitivity of the CMJ–sprint association observed in the female subgroup, CMJ results in adolescent female athletes should be interpreted cautiously and, when possible, alongside complementary sprint-specific assessments, such as kinematic measures of stride characteristics, to provide a more comprehensive evaluation of sprint performance [37]. Because maturation status was not independently associated with sprint time in this sample, post-PHV status should not be used alone to infer sprint performance or the strength of the CMJ-sprint relationship.

Lastly, due to the cross-sectional design of the study, these results should be interpreted as associations and as an indication of the model's explanatory power, avoiding any inference of a direct causal relationship between CMJ and sprint performance. As noted, this study has some limitations that should be considered. First, its cross-sectional design prevents the establishment of causal relationships between the analyzed variables. Second, although relevant anthropometric variables and maturation status were considered, biomechanical or electromyographic measurements were not included, which could have provided a deeper understanding of the mechanisms underlying the relationship between jumping and sprinting. Third, the inclusion of athletes from different sports constitutes a characteristic of the sample and possible source of interindividual variability, considering that sport specific demands and training characteristics may differ between disciplines. This consideration is particularly relevant in adolescents, because physical performance during this stage may be influenced by the interaction between growth, biological maturation, neuromuscular development, and training experience. Although maturation status was considered in the

present study, it was not significantly associated with 20 m sprint time. Therefore, it should be interpreted as descriptive and contextual information rather than as a demonstrated explanatory factor.

Finally, the smaller female subgroup (n = 43) relative to the number of predictors included in the sex-stratified model limited the precision and stability of the female-specific regression estimates. Accordingly, the non-significant associations observed in this subgroup should not be interpreted as evidence of absence. The relatively wide confidence interval surrounding the CMJ coefficient in females reflects this uncertainty. Although the CMJ × sex interaction was statistically significant in the primary analysis, sensitivity analysis showed that this interaction was substantially influenced by one valid influential observation in the female subgroup and was no longer statistically significant when this observation was excluded. Therefore, the extent to which the CMJ–sprint association differs between male and female adolescent athletes remains uncertain and requires confirmation in larger and more balanced samples. In addition, because maturation status was not significantly associated with 20 m sprint time, the extent to which maturation may contribute to potential sex-related differences remains unresolved. Future research should consider longitudinal designs, larger and more balanced samples of males and females, adequately powered formal interaction analyses involving sex and maturation status, and the inclusion of additional neuromuscular and biomechanical variables to better understand the factors associated with sprint performance in young athletes.

5. Conclusions

The results of this study indicate that countermovement jump (CMJ) performance is strongly associated with 20 m sprint performance in adolescent athletes, with greater jump heights associated with faster sprint times. CMJ emerged as the strongest predictor in the full-sample regression model. Although the primary analysis identified a significant CMJ × sex interaction, sensitivity analysis showed that this interaction was substantially influenced by one valid influential observation in the female subgroup and was no longer statistically significant when this observation was excluded. Sex-stratified analyses showed a clear negative association in males, whereas the female-specific estimate in the primary analysis was less precise and its confidence interval included zero. However, the female-specific association became stronger and statistically significant in the sensitivity analysis, further indicating that the female estimate was sensitive to the influential observation. Therefore, the present findings support a strong overall association between CMJ and sprint performance, whereas the extent to which this relationship differs between male and female adolescent athletes remains uncertain. The findings should not be interpreted as evidence of an absence of association in females or as robust evidence that sex moderates the CMJ–sprint relationship. Further research with larger and more balanced samples is required to determine whether sex consistently modifies this association. Overall, CMJ appears to be a practical and useful tool for assessing neuromuscular performance related to sprint ability in adolescent athletes, although sex-specific interpretations should be made cautiously until these findings are replicated.

Author Contributions: Conceptualization, C.H.-M., P.L.-V. and P.D.-F.; methodology, C.H.-M., H.C.-Q., S.P.-T. and P.D.-F.; Investigation, C.H.-M., P.L.-V., G.P.-A. and F.H.-P.; Formal analysis, P.L.-V. and J.L.-G.; writing—original draft preparation, H.C.-Q., R.E.-G., J.J.C.-N., J.A.A.-C., G.P.-A., F.H.-P. and J.L.-G.; writing—review C.H.-M., P.L.-V., S.P.-T. and P.D.-F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The protocol was approved by the Ethics Scientific Committee of the Adventist University of Chile (No. 2025-026).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: De-identified derived data and analysis code are available from the corresponding author on reasonable request, subject to institutional ethics and data-protection requirements.

Acknowledgments: Vicerrectoría de investigación y Postgrado (VRIP), Universidad del Bio-Bio, Chillán, Chile.

Conflicts of Interest: The authors declare no conflicts of interest.

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