



## Power, speed and flexibility of students at Industrial University of Santander

*Potencia, velocidad y flexibilidad de estudiantes de la Universidad Industrial de Santander*

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Received: 08-08-25

Accepted: 24-02-26

### How to cite in APA

Buitrago-Espitia, J. E., Jova-Elejalde, L., Villafrades  
González, F. A., & Reyes Parra, D. (2026). Power,  
speed and flexibility of students at Industrial  
University of Santander. *Retos*, 78, 503-511.  
<https://doi.org/10.47197/retos.v78.117366>

### Abstract

**Introduction:** The benefits of power, speed, and flexibility are recognised for the proper performance and health of the human body. However, the physical fitness of university students tends to decline as they progress through the academic programs.

**Objective:** To determine the relationship between power, speed, and flexibility of students at the Industrial University of Santander.

**Methodology:** A quantitative, cross-sectional, correlational study was conducted. Participants were students aged 18 or older who completed the study questionnaire. Height, body weight, flexibility, power, and speed were assessed using standardized physical tests. Descriptive statistics and correlation analyses were performed using SPSS.

**Results:** A total of 199 students (age  $20.13 \pm 2.19$  years; weight  $63.77 \pm 10.94$  kg; height  $168.68 \pm 8.66$  cm) were analysed. A positive correlation ( $r = .712$ ) was found between CMJ power (W) and maximum speed (m/s) of the 30 m sprint. Flexibility showed a non-significant negative correlation with CMJ power ( $r = -.005$ ) and maximum speed ( $r = -.050$ ).

**Discussion:** The findings of this study are in line with the correlations reported in amateur football players between CMJ power (W) with 30 m sprint ( $r = -.719$ ), and CMJ height with 30 m sprint ( $r = -.731$ ).

**Conclusion:** In the study population, a positive correlation was found between CMJ power and maximum speed in the 30 m sprint.

### Keywords

Acceleration; physical capacities; explosive strength; young university students; movement.

### Resumen

**Introducción:** Los beneficios de la potencia, velocidad y flexibilidad son reconocidos para el adecuado rendimiento y salud del cuerpo humano. La aptitud física de los estudiantes universitarios disminuye a medida que avanzan en el programa académico.

**Objetivo:** Determinar la relación entre la potencia, velocidad y flexibilidad de los estudiantes en la Universidad Industrial de Santander.

**Metodología:** Se realizó un estudio cuantitativo, transversal y de alcance correlacional. Participaron estudiantes mayores de 18 años que respondieron el cuestionario del estudio, se determinó la altura, peso corporal, flexibilidad, potencia y velocidad de los participantes mediante pruebas físicas. El análisis estadístico descriptivo y las correlaciones de los datos se realizaron en el software SPSS.

**Resultados:** Se analizaron 199 estudiantes (edad  $20.13 \pm 2.19$  años; peso  $63.77 \pm 10.94$  kg; altura  $168.68 \pm 8.66$  cm). Se halló correlación positiva ( $r = .712$ ) entre la potencia (W) del CMJ y la velocidad máxima (m/s) del sprint de 30 m, mientras que la flexibilidad tuvo correlación negativa no significativa con la potencia CMJ ( $r = -.005$ ) y la velocidad máxima ( $r = -.050$ ).

**Discusión:** Los resultados de este estudio están en la misma línea de las correlaciones reportadas en estudios de entre la potencia (W) del CMJ con la velocidad en 30 m ( $r = -.719$ ), y la altura del CMJ con la velocidad en 30 m ( $r = -.731$ ).

**Conclusión:** En la población objeto de estudio se halló una correlación positiva entre la potencia del CMJ y la velocidad máxima en el sprint de 30 m.

### Palabras clave

Aceleración; capacidades físicas; fuerza explosiva; jóvenes universitarios; movimiento.

## Introduction

Flexibility, speed, and power are key components of physical fitness and play an important role in human performance and health (Görner & Reineke, 2020) and influence the performance and health of the human body (López-Sánchez et al., 2020). Although each of these capacities serves a specific function, their combined development can enhance overall physical performance.

Regarding flexibility, several studies have reported a decline in physical fitness among physical education students as they progress through their academic programs (Bonilla et al., 2023). In addition, first-year physical education, nutrition, and dietetics students showed greater flexibility compared to second- and third-year students in the respective programs (Parra-Soto et al., 2023). It has also been reported that women tend to have higher levels of flexibility compared to men among Colombian students (Bonilla et al., 2023), Chinese students (Lu et al., 2022b), and Taiwanese students (Kung et al., 2020). However, other studies have found no significant differences between men and women in the Sit and Reach test in Chinese students (Zheng et al., 2022), Canadian kinesiology students (O'Brien et al., 2022), Saudi Arabian students (Pacholek et al., 2021), and Balearic Islands students (Muntaner-Mas et al., 2021). On the other hand, it has been evidenced that the implementation of stretching and Pilates exercises improves results in these tests (Lazăr & Leuciuc, 2021).

With respect to speed, previous studies have reported differences in 30 m sprint performance between female university students from Spain and Poland, with Spanish students showing faster sprint times (López-Sánchez et al., 2020). In general, men tend to demonstrate higher sprint performance than women. Additionally, students in their second year or beyond tend to show lower sprint performance than first-year students; however, some evidence suggests a gradual improvement in sprint ability throughout university life (Bonilla et al., 2023). Both studies report the 30 m sprint results in seconds.

In terms of power, the literature consistently indicates that male students outperform female students in the Countermovement Jump (CMJ) test in samples from the United Kingdom (Wilson-Barnes et al., 2021), Spain and Poland (López-Sánchez et al., 2020), (López-Sánchez et al., 2019), and Chile (Parra-Soto et al., 2023). These differences may be explained by sex-related variations in muscle mass, strength levels, and body composition.

Given the relevance of flexibility, speed, and power to health and physical performance, it is important to assess the status of these capacities in university populations. In Colombia, however, the available evidence remains limited. Therefore, this study aimed to determine the relationship between power, speed, and flexibility in students at the Industrial University of Santander.

## Method

A cross-sectional quantitative study was conducted in which general data, height, weight, flexibility, power, and speed of the participants were obtained through physical tests performed at a single point in time.

### *Participants*

Potentially healthy students aged 18 years or older who were officially enrolled at the Industrial University of Santander were included. Participants were instructed to avoid intense physical training for 24 hours before testing and to refrain from consuming energy drinks, alcohol, caffeine, or psychoactive substances on the day of testing.

Exclusion criteria included the presence of injuries, illnesses, or use of medications that could affect physical performance or prevent completion of the study tests. Random sampling was used, and no a priori sample size calculation was performed.

The study protocol was approved by the Scientific Research Ethics Committee of the Industrial University of Santander (CEINCI; approval No. 7, May 12, 2023). All participants provided written informed consent before participation.



## Procedure

Each participant completed the tests in approximately 45 minutes, following the established order, which consisted of collecting general data (name, age, gender, marital status, occupation, academic program, socioeconomic status, date of testing, telephone number).

### Instrument and tests

Body mass was measured using a bioelectrical impedance scale (Tanita BC-1500) with an accuracy of 0.1 kg. Stature was measured barefoot using a portable stadiometer (Seca 213) with an accuracy of 0.1 cm.

Flexibility was determined using the classic Sit and Reach test following standardization guidelines (O'Brien et al., 2022), to find power the CMJ test was performed using the My Jump 2 application (Brooks et al., 2018), (Bogataj, Pajek, Hadžić, et al., 2020), (Bogataj, Pajek, Andrašić, et al., 2020), (Jimenez-Olmedo et al., 2022), each participant was guided to perform joint mobility and warm-up exercises, especially of the lower limbs, which included squats, jumps. Each participant performed the test twice and the best result was taken.

The order for measuring physical abilities was 1) Flexibility using the classic Sit and Reach test following standardization guidelines (O'Brien et al., 2022), 2) Power using the CMJ test using the My Jump 2 app (Bogataj, Pajek, Andrašić, et al., 2020; Bogataj, Pajek, Hadžić, et al., 2020; Brooks et al., 2018; Jimenez-Olmedo et al., 2022); each participant was guided to perform joint mobility and warm-up exercises, especially for the lower limbs, which included squats and jumps. Each participant performed the test twice, and the best result was recorded. 3) Speed was measured in a 30 m sprint using the MySprint app (Romero-Franco et al., 2017). Before testing, participants were instructed on the procedure and performed a 20 m progressive run to familiarize themselves with it. The test was performed once, individually, and when it was necessary to repeat the test, a five-minute break was given. In addition, a break of at least 15 minutes was established between the power and speed tests. Each participant wore their own athletic shoes. The measurements were taken in November 2023 and February 2024 in the physical exertion laboratory of the Department of Physical Education and Sports and on the UIS athletics track, which has a non-slip slurry surface. All measurements were performed by the same investigators.

## Data analysis

Statistical analyses were conducted using SPSS Statistics (version 31.0.0.0). Descriptive statistics (minimum, maximum, mean, and standard deviation) were calculated. Data normality was assessed using the Kolmogorov–Smirnov test. The significance level was set at 0.05, with 95% confidence intervals. Pearson's correlation coefficient was used for normally distributed variables, and Spearman's rho was applied for non-normally distributed variables. Comparisons between women and men were performed using the independent-samples t-test or the Mann–Whitney U test, depending on data distribution.

## Results

A total of 199 students were evaluated, mean age  $20.13 \pm 2.19$  years; weight  $63.77 \pm 10.94$ kg; and height  $168.68 \pm 8.66$  cm. The participants' characteristics, grouped by gender, are shown in Table 1.

Table 1. Comparison of general characteristics, power, speed, and flexibility between female and male students at the UIS.

Variable	Women (n = 75)	Men (n = 124)	Sig. <sup>a,b</sup>	Effect size <sup>d</sup>
Age (years)	19.76 ± 1.95	20.35 ± 2.3	<.060 NS	NA
Weight (kg)	57.15 ± 8.39	67.78 ± 10.36	<.001	NA
Height (cm)	160.71 ± 5.65	173.51 ± 6.27	<.001 <sup>c</sup>	6.04
Sit and Reach (cm)	3.83 ± 8.75	0.78 ± 9.86	<.028	NA
CMJ Height (cm)	23.51 ± 5.35	33.53 ± 6.67	<.001 <sup>c</sup>	6.21
CMJ Flight time (ms)	435.13 ± 49.16	520.44 ± 51.43	<.001 <sup>c</sup>	50.59
CMJ Force (N)	876.76 ± 176.0	1172.09 ± 220.52	<.001 <sup>c</sup>	204.93
CMJ Velocity (m/s)	1.06 ± 0.12	1.27 ± 0.12	<.001 <sup>c</sup>	.12
CMJ Power (W)	942.54 ± 254.19	1505.22 ± 360.23	<.001	NA
D5 m (s)	1.4 ± 0.09	1.24 ± 0.09	<.001	NA
D10 m (s)	2.34 ± 0.16	2.04 ± 0.13	<.001	NA
D15 m (s)	3.21 ± 0.23	2.77 ± 0.18	<.001	NA
D20 m (s)	4.07 ± 0.31	3.47 ± 0.24	<.001	NA



D25 m (s)	4.95 ± 0.41	4.18 ± 0.3	<.001	NA
D30 m (s)	5.8 ± 0.48	4.86 ± 0.37	<.001	NA
$V_{max}$ (m/s)	5.84 ± 0.54	7.2 ± 0.63	<.001	NA
$F_o$ (N)	533.21 ± 137.17	709.13 ± 143.28	<.001	NA
$F_o$ (N/kg)	9.16 ± 1.37	10.48 ± 1.58	<.001	NA
$V_o$ (m/s)	5.97 ± 0.57	7.37 ± 0.66	<.001	NA
$P_{max}$ (W)	796.1 ± 215.3	1297.48 ± 310.28	<.001	NA
$P_{max}$ (W/kg)	13.71 ± 2.6	19.38 ± 3.61	<.001 <sup>c</sup>	3.27
DRF (%)	-0.14 ± 0.26	-0.13 ± 0.02	<.001	NA
FV	-90.16 ± 25.47	-96.72 ± 21.1	<.008	NA
RF 10 m (%)	0.24 ± 0.02	0.28 ± 0.02	<.001	NA
RF <sub>max</sub> (%)	0.5 ± 0.03	0.57 ± 0.03	<.001	NA

Mean ± Standard Deviation

Mann-Whitney U test for independent samples. a. Significance level is .050. b. Asymptotic significance is shown. c. Independent samples t-test. NA Not Apply. NS difference Not Significant, CMJ Countermovement Jump,  $V_{max}$  maximal velocity,  $F_o$  theoretical maximal force,  $V_o$  theoretical maximal velocity,  $P_{max}$  maximal power output, DRF slope of the linear decrease on ratio of force as sprint velocity increases, RF ratio of force, RF<sub>max</sub> maximal value of RF.

In statistical processing, height (cm), Pmax (W/kg), CMJ height (cm), CMJ flight time (ms), CMJ force (N), and CMJ velocity (m/s) had a normal distribution. In the comparison between women and men, age (years) was the only variable with no significant difference, while Sit and Reach flexibility (cm) was the only variable in which women had higher values than men.

Using Pearson's test, strong correlations were found between CMJ height (cm) and CMJ flight time (ms)  $\rho$  0.996 (95% CI, 0.994-0.997), CMJ height (cm) with CMJ velocity (m/s)  $\rho$  0.996 (95% CI, 0.994-0.996), between CMJ flight time (ms) and CMJ velocity (m/s)  $\rho$  0.999 (95% CI, 0.999-0.999), positive correlations between height (cm) and Pmax (W/kg)  $\rho$  0.535 (95% CI, 0.427-0.999). All correlations were significant at the 0.01 (bilateral) level (Table 2).

Table 2. Pearson correlations between CMJ height (cm), CMJ flight time (ms), CMJ velocity (m/s), and the variables investigated in UIS students (n = 199).

Variable	CMJ height (cm)	CMJ flight time (ms)	CMJ velocity (m/s)	Pmax (W/kg)	Height (cm)
CMJ height (cm)	---	.996**	.996**	.663**	.505**
CMJ flight time (ms)	.996**	---	1.000**	.670**	.516**
CMJ velocity (m/s)	.996**	1.000**	---	.671**	.515**
Pmax (W/kg)	.663**	.670**	.671**	---	.535**
Height (cm)	.505**	.516**	.515**	.535**	---

\*\* . Correlation is significant at the level 0.01 (bilateral).

On the other hand, Spearman's Rho test found positive correlations between CMJ Power (W) and Vmax (m/s)  $r$  0.712 p-value < 2.2e-16, and negative correlations between Sit and reach (cm) and CMJ Power (W)  $r$  -0.004 p-value = 0.949, Sit and reach (cm) and Vmax (m/s)  $r$  -0.049 p-value = 0.483 (Table 3).

Table 3. Spearman's Rho correlations between power, speed, flexibility, and the variables investigated in UIS students (n = 199).

Variable	CMJ Power (W)	Vmax (m/s)	Sit and reach (cm)
CMJ Power (W)	---	.712**	-.005
Vmax (m/s)	.712**	---	-.050
Sit and reach (cm)	-.005	-.050	---
Age (years)	.210**	.216**	-.131
Weight (kg)	.647*	.351**	-.060

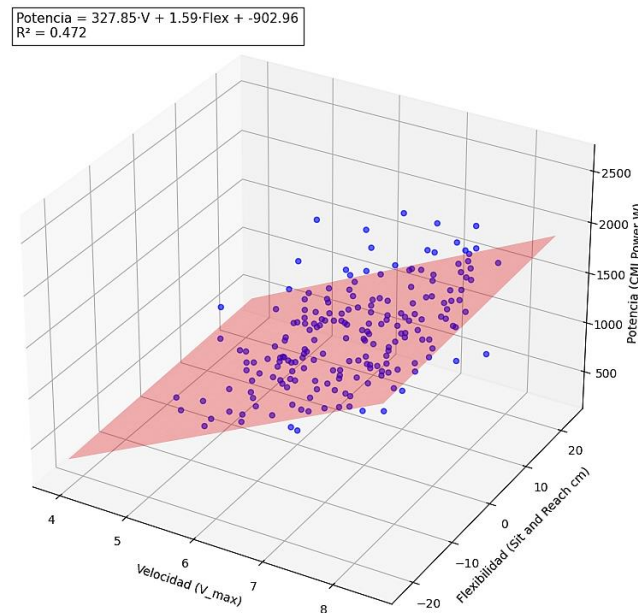
\*\* . Correlation is significant at the level 0.01 (bilateral).

\* . Correlation is significant at the level 0.05 (bilateral).

A multiple linear regression model was applied where the dependent variable was CMJ Power (W), and the independent variables were Vmax (m/s) and Sit and reach (cm). Vmax had a coefficient of 327.57 (95% CI, 278.97-376.73), indicating a strong influence on power. Sit and reach had a coefficient of 1.59 (95% CI, -2.96-6.13), confirming that its contribution is minimal. The intercept had a coefficient of -902.96 (95% CI, -1233.41 - -572.50). The coefficient of determination was 0.472, meaning that 47.2% of the variability in power is related to the independent variables (Figure 1).



Figure 1. Multiple linear regression of power, speed, and flexibility.



Using standardized coefficients, the equation can be expressed as follows: CMJ Power = 0.688•Vmax + 0.036•Sit and Reach + -902.96, with adjusted R<sup>2</sup> = 0.466. In testing the assumptions, the residual normality test (Shapiro-Wilk) yielded  $p = 0.0019$  and the error independence test (Durbin-Watson) 1.854, while the homoscedasticity test (Breusch-Pagan) had LM  $p$ -value = 0.1827 and F  $p$ -value = 0.1847.

Overall, the combined correlation and regression analyses indicate a significant and positive relationship between sprint speed and jump power, suggesting that higher sprint speed is associated with greater lower-limb power, whereas flexibility does not appear to significantly influence either variable.

## Discussion

The purpose of this study was determine the relationship between the power, speed, and flexibility of students at the Industrial University of Santander, a positive correlation ( $r = .712$ ) was found between CMJ power (W) and maximum speed (m/s) of the 30 m sprint, this results is similar to that found by Barrera et al. (2021), in Chilean soccer players ( $n = 169$ ) or U13 and U19 categories where the correlations between CMJ power (W) and time in the 30 m speed test were ( $r = -.719$ ), CMJ height with time in the 30 m speed test ( $r = -.731$ ), and the correlation found by Perwira Bakti et al. (2024) in students aged 10 to 12 ( $n = 61$ ) between CMJ jump height and leg power versus sprint capacity ( $r = -.715$ ). It is important to note that the negative correlations between power and the speed test in the study by Barrera et al. (2021) were due to the way the variables were measured. In this case, the 10 and 30 meter speed tests were recorded in time, with this variable moving in the opposite direction to the power and CMJ height variables, respectively.

In the study of Yusni et al. (2025) conducted on amateur soccer players ( $n = 31$ ) between 18 and 22 years old from Indonesia, a non-significant negative correlation was found between body weight and flexibility ( $r = -0.13$ ;  $p = 0.50$ ). Compared to our study, this correlation was ( $r = -.060$ ;  $p = 0.39$ ). In addition, non-significant negative correlations were found between flexibility and CMJ power ( $r = -.005$ ) and between flexibility and maximal speed ( $r = -.050$ ).

In similar studies, O'Brien et al. (2022) investigated two cohorts of Canadian students (Pre and Post 30 years). The mean age, height, and weight of Pre females ( $n = 75$ ) were  $19.4 \pm 3.0$  years,  $166.1 \pm 6.5$  cm,  $62.5 \pm 9.2$  kg, and males ( $n = 103$ ) were  $19.4 \pm 2.1$  years,  $178.6 \pm 6.0$  cm,  $78.0 \pm 10.0$  kg. In the Post 30 cohort, the females ( $n=219$ ) were  $19.0 \pm 2.0$  years,  $166.3 \pm 7.1$  cm,  $66.3 \pm 9.6$  kg, while males ( $n=129$ ) were  $19.3 \pm 2.0$  years,  $178.4 \pm 7.1$  cm,  $80.4 \pm 13.8$  kg. Compared to the females ( $n=75$ ;  $9.6 \pm 1.95$  years,

160.71 ± 5.65 cm; 57.15 ± 8.39 kg) and males (n=124; 20.35 ± 2.3 years, 173.51 ± 6.27 cm, 67.78 ± 10.36 kg) who participated in this study, the greater height and body weight of Canadian females and males is evident.

In terms of power and vertical jump height, Pre women had 3239 ± 642 W and 40.1 ± 7.9 cm, and men had 4824 ± 640 W, 57.0 ± 8.4 cm, 28.4 ± 15.7 cm. In the Post30 cohort, women had 3243 ± 816 W and 37.9 ± 9.9 cm, and men had 4859 ± 882 W and 53.6 ± 10.2 cm. In comparison, the women in this study had 942.54 ± 254.19 W and 23.51 ± 5.35 cm, and the men 1505.22 ± 360.23 W and 33.53 ± 6.67 cm. These results are lower, indicating that the test used to measure the jump differed between these studies. On the other hand, in flexibility the Pre women and men had 32.0 ± 18.0 and 28.4 ± 15.7 cm, and Post30 33.5 ± 10.7 y 30.6 ± 9.0 cm, respectively. These values exceed the results of women (3.83 ± 8.75 cm) and men (0.78 ± 9.86 cm) in this study.

For their part, in the analysis of Chilean students Parra-Soto et al. (2023) investigated women (n = 70) with an average age 22.7 ± 2.3 years and men (n = 88) 22.3 ± 2.7 years, who had a CMJ height 25 ± 5.5 cm and 34.8 ± 6.0 cm, flexibility (Sit and Reach) 30.5 ± 10.1 cm and 28.9 ± 9.2 cm, respectively. Compared to UIS students, CMJ height data are close (females 23.51 ± 5.35 cm, males 33.53 ± 6.67 cm), while flexibility values are much lower (women 3.83 ± 8.75 cm, men 0.78 ± 9.86 cm).

In national context, Bonilla et al. (2023), analyzed university students in Bogotá, including women (n = 97) and men (n = 445), with average age, height, and weight of 19.4 ± 2.2 years, 159.2 ± 5.9 cm, 57.8 ± 8.6 kg, and 20.0 ± 2.2 years, 171.7 ± 6.2 cm, 67.8 ± 9.8 kg, respectively.

The results are presented across the students' first to fourth years of study, including 30 m sprint times of 8.0 ± 2.0 s, 6.5 ± 2.2 s, 7.8 ± 0.7 s, and 6.6 ± 2.0 s, and Sit and Reach scores of 4.9 ± 8.3 cm, 5.3 ± 9.5 cm, 9.2 ± 8.1 cm, and 5.2 ± 8.6 cm, respectively. These data are similar when compared with UIS students, including women (n=75) and men (n=124), with average ages, heights, and weights of 19.76 ± 1.95 years, 160.71 ± 5.65 cm, and 57.15 ± 8.39 kg, and 20.35 ± 2.3 years, 173.51 ± 6.27 cm, and 67.78 ± 10.36 kg, respectively. The 30 m sprint times were better in women (5.8 ± 0.48 s) than in men (4.86 ± 0.37 s). Regarding flexibility, women scored lower (3.83 ± 8.75 cm) than men (0.78 ± 9.86 cm).

In general, the results for the 30 m sprint, power, and height in the CMJ test of the participants in this study are consistent with previous research by López-Sánchez et al. (2019) who reported that males from Gdansk, Poland (n = 81) scored 4.40 ± 0.19 s and 4064.50 ± 538.02 W, 41.65 ± 5.66 cm, and Murcia, Spain (n = 105) 4.43 ± 0.28 s, 3410.35 ± 539.33 W, 33.68 ± 5.80 cm performed better than females López-Sánchez et al. (2020) Gdansk, Poland (n = 188) 5.19 ± 0.33 s, 2418.63 ± 478.33 W, 28.58 ± 4.57 cm, and Murcia, Spain (n = 42) 5.15 ± 0.34 s, 2200.52 ± 610.94 W, 23.51 ± 4.03 cm, respectively, and the findings reported in the studies by O'Brien et al. (2022), Bonilla et al. (2023), Parra-Soto et al. (2023). However, the results for women and men in this study are lower than the data reported in the referenced studies. As reported by Lu et al. (2022b), women (n = 768) had better flexibility (16.04 ± 5.99 cm) than men (n = 730) (12.34 ± 6.28 cm). According to Bonilla et al. (2023) and Parra-Soto et al. (2023), the women in this study had better flexibility results than the men. However, this was the variable with the greatest difference, with the students in this study performing much worse than in previous studies.

## Conclusions

In this study, a positive correlation was observed between CMJ power and maximum speed in the 30 m sprint among students at the Industrial University of Santander; this suggests that the ability to exert force in the shortest possible time may be associated with greater sprint speed. It was found that flexibility has little influence on CMJ jump power and maximum speed. It should be noted that the flexibility results in this study are much lower than those reported in studies conducted with university student populations. The 30 m sprint speed was the only result in which UIS students outperformed those from the University of Bogotá. In general, the power, speed, and flexibility results of UIS students are lower than those reported in the reference studies.



## Limitations

The main limitations of this study include the sample size, which limits the generalizability of the findings, and the cross-sectional design, which prevents causal inferences and deeper exploration of the factors underlying the observed results. Future research should include larger samples, incorporate longitudinal designs, and explore potential determinants of physical fitness levels in university students.

## Practical implications

This study provides valuable information on the current state of students' speed, power, and flexibility at the Industrial University of Santander, facilitating a characterization based on objective data obtained through validated tests. These data can contribute to the design of physical activity and sports strategies that enhance physical abilities, contributing to the comprehensive physical development of students.

## Acknowledgments

We would like to thank all the participants and teachers who contributed to the success of this research.

## Financing

This research was funded entirely by the Industrial University of Santander.

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