Noncommunicable diseases in relation to body composition and physical condition in tertiary education

Enfermedades no transmisibles en relación con composición corporal y condición física en educación terciaria

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Abstract

Introduction: The life of the tertiary education student presents different behavioral aspects that influence the risk of acquiring non-communicable diseases, some related to their body composition and physical condition.
Objective: which leads to the research objective of relating the risk factors of acquiring non-communicable diseases with body composition and physical activity in tertiary education.
Methodology: 1020 students (526 males and 494 females) were evaluated; a quantitative, observational, prospective, descriptive and relational cross-sectional study; a stratified, representative, probabilistic sample of students was evaluated; body composition was determined by body weight and standing height; physical condition was considered in terms of cardiorespiratory capacity (Leger test) and manual prehensile strength.
Results: all study variables were significantly higher in men; anthropometric data reveal significant differences between sexes in terms of weight and height, most students have a body composition in the healthy range. the distribution of grip strength of men is more uniform between institutions; in women, differences between universities are more pronounced. Cardiorespiratory capacity values are concentrated around the 40 to 50 (Adequate) range.
Conclusions: tertiary education students present a physical condition above adequate, contributing to reduce physical inactivity, sedentary lifestyle and the acquisition of non-communicable diseases.

Keywords

Exercise behavior; mental health; physical activity; sedentary.

Resumen

Introducción: La vida del estudiante de educación superior presenta diferentes aspectos conductuales que influyen en el riesgo de padecer enfermedades no transmisibles, algunos relacionados con su composición corporal y su condición física.
Objetivo: relacionar los factores de riesgo de padecer enfermedades no transmisibles con la composición corporal y la actividad física en la educación superior.
Metodología: se evaluó a 1020 estudiantes (526 hombres y 494 mujeres); se realizó un estudio cuantitativo, observacional, prospectivo, descriptivo y transversal relacional; se evaluó una muestra estratificada, representativa y probabilística de estudiantes; se determinó la composición corporal mediante el peso corporal y la estatura en posición de pie; se consideró la condición física en términos de capacidad cardiorrespiratoria (prueba de Leger) y fuerza de prensión manual.
Resultados: todas las variables del estudio fueron significativamente más altas en los hombres; los datos antropométricos revelan diferencias significativas entre los sexos en términos de peso y estatura, la mayoría de los estudiantes tienen una composición corporal dentro del rango saludable. La distribución de la fuerza de prensión de los hombres es más uniforme entre las instituciones; en las mujeres, las diferencias entre universidades son más pronunciadas. Los valores de la capacidad cardiorrespiratoria se concentran en torno al rango de 40 a 50 (adecuado).
Conclusiones: los estudiantes de educación terciaria presentan una condición física por encima de lo adecuado, lo que contribuye a reducir la inactividad física, el estilo de vida sedentario y la adquisición de enfermedades no transmisibles.

Palabras clave

Actividad física, conducta sedentaria; salud mental; sedentarismo.

Introduction

Risk of Developing Non-Communicable Diseases

Currently, humanity is witnessing an alarming increase in the risk of developing noncommunicable diseases (NCDs) such as cardiovascular diseases, certain types of cancer, chronic respiratory diseases, and diabetes. Global and regional health organizations have raised concerns about the significant impact of these diseases on the daily lives of children, adolescents, adults, and the elderly. These conditions are typically characterized by a gradual and often imperceptible progression, largely due to their association with various risk factors, including stress, sedentary lifestyles, physical inactivity (Estrada et al., 2025; Guthold et al., 2020; Booth et al., 2017), unhealthy dietary habits, the use of psychoactive substances, and obesity, among others (Booth et al., 2017; WHO, 2017; Beltrán-Carrillo et al., 2017).

Empirical evidence suggests that NCDs are major contributors to mortality, with the following conditions being most prevalent: a) cardiovascular diseases (myocardial infarction, stroke), b) certain types of cancer, c) chronic respiratory diseases (asthma and chronic obstructive pulmonary disease), d) diabetes, and e) renal disorders (Carrillo et al., 2025; WHO, 2022; PAHO, 2022). Notably, metabolic risk factors significantly contribute to the increased likelihood of developing these diseases, given their strong association with sedentary behaviors and physical inactivity (Guthold et al., 2020; Booth et al., 2017). These factors include hypertension, overweight and obesity, hyperglycemia (elevated blood glucose levels), and hyperlipidemia (elevated blood lipid levels) (WHO, 2022; PAHO, 2022; IHME, 2019).

University students, in particular, face a series of lifestyle challenges and changes that contribute to the development of these diseases. The transition from adolescence to adulthood, coupled with the onset of university life and its academic and social demands, often fosters the formation of both healthy and unhealthy habits. This, in turn, increases physical inactivity and elevates the risk of chronic diseases, highlighting the significant impact of NCDs on national productivity and healthcare costs (Carrillo et al., 2025; WHO, 2022; PAHO, 2022).

Body Composition

Body Composition (BC) is a significant predictor of metabolic and cardiovascular diseases (Parada & Gálvez, 2022). BC refers to the distribution of fat and non-fat components in the body, encompassing five primary elements: fat, muscle, bone, skin, and residual mass, along with tissues such as fat, protein, minerals, and body water (Pico et al., 2021; Hoeger, 1996). The assessment of BC is crucial for establishing healthy proportions, as targeted physical activity can lead to beneficial changes in BC. For instance, studies have shown that women can improve bone mass and lean soft tissue mass, while in men, BC (as measured by BMI), physiological parameters, and blood lipid levels also show improvement (Cebrian-Ponce et al., 2024).

BC assessment is widely used to monitor and verify the health status of the general population (Parada & Gálvez, 2022). While Body Mass Index (BMI)—the ratio of body mass (kg) to height squared (m^2)—is often used to evaluate the appropriateness of an individual's weight relative to their height, it does not distinguish between the types of tissues that constitute total body mass. What the, BC assessment through anthropometry, combined with physical fitness evaluation, can serve as more significant indicators of overall health.

Physical Fitness

Physical fitness is defined as the ability to perform muscular activity or work effectively (Ruiz-Castellanos et al., 2021; Chacón-Borrego et al., 2020; Caspersen et al., 1985), comprising a set of attributes possessed by an individual that are closely related to physical activity (Chacón et al., 2020). Key components of physical fitness include cardiorespiratory and muscular endurance, muscle strength, flexibility, and body composition, all of which are predominantly linked to health (Ruiz-Castellanos et al., 2021; Chacón-Borrego et al., 2020). The physical fitness as a biological predictor of an individual's general health status (Rosa-Guillamón, 2019; Gea-García et al., 2020).

Regular physical activity is associated with improvements in physical fitness, particularly aerobic capacity, which has been shown to be a reliable indicator of adolescent health (Galán-Arroyo et al., 2024; Chacón-Borrego et al., 2020). Moreover, a study conducted among men at cardiovascular risk revealed

a lower mortality risk in those with higher levels of muscle strength (Araújo et al., 2025; Lopez-Jaramillo et al., 2022). Additionally, another study involving young adults aged 18 to 24 found that those with greater muscle strength exhibited a healthier lipid-metabolic profile compared to those with lower muscle strength (Peña-Ibagon et al., 2021; Pasdar et al., 2019). Consequently, the evaluation of physical fitness is of paramount importance, as it provides critical diagnostic information regarding an individual's health status.

Higher Education

The Ministry of National Education of Colombia proposes the National System of Tertiary Education (SNET) as the administrative framework that encompasses the various levels of education pursued after completing secondary studies (including technical, undergraduate, and postgraduate programs). These are categorized based on their focus, such as professional (technological) training and academic or professional university education (undergraduate and postgraduate) (MEN, 2024; Villalobos et al., 2022).

The SNET is grounded in principles of inclusion, emphasizing lifelong learning from admission through to graduation. This includes ensuring accessibility in curriculum, methodologies, and assessments, while also considering the various dimensions of the human being—social, physical-motor, spiritual, and emotional (MEN, 2024; Brito et al., 2019; Scarfó, 2015).

Based on the above considerations, research into the physical fitness and body composition of young people, specifically those in higher education and the consequences that result, will make it possible to determine and predict whether or not NCDs will increase in these populations, since no correlation has been established between the variables studied in university students in Colombia.

In line with these principles, it is possible to determine risk factors for the acquisition of noncommunicable diseases. The objective of this study is to determine the prevalence of noncommunicable diseases (NCDs) among tertiary education students, explore their relationship with body composition (BC) and physical fitness (PF), and identify possible risk factors for cardiovascular (CVD) and metabolic diseases in this population.

Method

Study Type

This research employed a quantitative approach with a cross-sectional design, as data were collected at a single point in time to explore the relationship between noncommunicable diseases (NCDs), body composition (BC), and physical fitness in Colombian tertiary education students. The study was descriptive in scope, detailing and analyzing numerical data for the variables involved. It was conducted within a non-experimental and observational framework, meaning that the variables were observed in their natural environment without any intervention. The research also included a correlational analysis, allowing for the prospective interpretation of possible future trends in the studied communities (Hernandez-Sampieri et al., 2020).

Participants

This study was based on the collection and analysis of numerical data from undergraduate students at the Universidad de Caldas, Universidad Nacional de Colombia, Manizales campus, and CINOC, focusing on evaluating Body Mass Index (BMI), cardiorespiratory capacity, and Manual Grip Strength (MPF). These measures were used to identify the risk of developing NCDs. The total undergraduate enrollment across these universities during the 2022-2, 2023-1, and 2023-2 academic periods was approximately 20,000 students. Of these, 1,020 students were tested, including 543 students from professional undergraduate programs and 477 from technology and special programs, spanning 9 faculties and 48 programs (352 students from Universidad de Caldas, 477 from CINOC, and 191 from Universidad Nacional). The sample included both male and female students aged between 16 and 61 years.

A probabilistic sampling method with a multi-stage design was employed as follows: Initially, one semester was selected from each academic program. Then, a complete course from each undergraduate program was invited to participate at a specific time, prearranged with the students and the faculty

responsible for the courses. This approach ensured that all undergraduate programs at the institutions were represented and that a large portion of the students in the selected sample participated. A total of 623 students (223 men and 244 women) from 10 semesters and 30 undergraduate programs were evaluated.

The following were considered inclusion criteria: being enrolled as an active student at one of the participating institutions, be enrolled in a higher education program and voluntarily agree to participate by signing a written Express (Explicit) Consent form. Students with a medical diagnosis that precluded them from participating in physical tests were excluded, with musculoskeletal injuries that would limit their ability to perform the assessments, while pregnant, under the influence of substances or medications that impair physical performance, or with incomplete data records.

Procedure

All participating students had their personal data collected and recorded in individual electronic files. To assess BMI, body mass was measured using a SECA813® digital floor scale, and height was measured using a SECA213® stadiometer, with a measurement range of 0-220 cm.

To evaluate respiratory capacity (Vo2max), the Léger test or Course Navette test (20m SRT) was administered. Vo2max was indirectly calculated using the results from the test and the Léger formula. For participants under 18 years of age, Vo2max was determined as follows: Vo2max = 31.025 + (3.238 · V) - (3.248 · E) + (0.1536 · V · E). For participants over 18 years of age, the formula used was Vo2max = (5.857 · V) - 19.458. In these formulas, V represents the speed at which the participant stopped, and E represents the participant's age in completed years.

For the interpretation of the Léger test, the study by García and Secchi (2014) was referenced. The test results are expressed in liters per minute (L/min) or milliliters per kilogram per minute (ml/kg/min). The test is incremental and maximal, requiring participants to run back and forth between two lines 20 meters apart, following a pace set by the 20m SRT protocol. The test starts at a speed of 8.5 km/h, increasing by 0.5 km/h each minute. Participants were guided by an auditory signal from a Bluetooth sound system (J&R Technology brand, model J 5194, with tripod).

All students were gathered in a large, open space, and were briefed on the Léger or Course Navette test beforehand. The test was conducted at a pre-scheduled time, coordinated with both instructors and students. Participants were instructed 24 hours in advance to avoid consuming alcoholic beverages, psychoactive substances, or medications that could alter their physical condition.

For the Manual Grip Force (MPF) test, which measures grip strength in kilograms, a Takei Physical Fitness Test dynamometer, model GRIP-D, with an accuracy of 0.5 kgf, was used. The test was performed in a standardized position: the participant stood with their arms parallel to their body, holding the dynamometer without letting it touch their body. The participant applied gripping force for at least three seconds. Each participant made two attempts with both their dominant and non-dominant hands, with a one-minute rest between attempts. The best result was recorded on the individual assessment sheet.

Based on the results from the BC assessment, dynamometry, and Vo2max measurements, relationships and risk categorizations were established at different levels, according to criteria found in the scientific literature. This allowed for the identification of potential NCD developments.

Data analysis

The data collected from the study variables were compiled into an Excel matrix. Descriptive statistics were then performed to summarize the student sample according to gender and academic institution, focusing on body composition (BMI), cardiovascular risk (assessed via VO2max), and manual grip strength (MPF). The anthropometric characteristics, MPF, and cardiovascular fitness (CF) of the study sample are presented as means with standard deviations (SD) and 95% confidence intervals (95% CI), unless otherwise specified.

The normality of the variables was assessed using the Kolmogorov-Smirnov test, which allowed us to determine the appropriateness of subsequent statistical procedures. To analyze differences in anthropometric variables, handgrip strength, and cardiorespiratory fitness between genders and institutions, a two-way analysis of variance (ANOVA) was performed. This test was chosen because it allowed for the comparison of means between independent groups in a cross-sectional design, without

attempting to establish causal relationships or perform multivariate adjustments, which go beyond the descriptive-relational scope of the study.

The observed trends for the mean (M) and coefficient of variation (S) were similarly smoothed. These LMS curves contained the necessary information to draw any percentile curve and to convert measurements into exact standard deviation scores. The data were imported into OriginPro® 2018 software for the construction of the percentile curves, and the L, M, and S curves were estimated. Comparisons between the tests and retests (T1 and T2) were made for both men and women using scatter plots across the entire sample (526 men and 494 women).

Following the initial data analysis, additional tests were conducted to deepen the understanding of the observed relationships and differences. Correlations were explored by calculating the Spearman correlation coefficient to investigate the relationships between the variables of interest. Group comparison tests, such as ANOVA, were also applied to examine the differences between various student groups in these measures.

Importantly, the study was conducted with strict adherence to ethical guidelines. Approval was obtained from the Ethics Committee of each participating institution. The study followed the ethical principles outlined in the Declaration of Helsinki. Participant data confidentiality was ensured, and all participants provided informed consent before their inclusion in the study.

Results

The average anthropometric, body composition, and physical condition characteristics of the study sample, disaggregated by sex, are presented in Table 1. Overall, all study variables were significantly higher in men compared to women. Additionally, the anthropometric and fitness characteristics did not follow a Gaussian distribution, as illustrated in Figures 1, 2, and 3.

Table 1 provides a detailed analysis of the average characteristics of the study sample, which consists of 1020 participants, including 526 men and 494 women. The average age of the participants was approximately 21.2 years, with minimal variation between men and women, indicating a homogeneous age distribution within the sample.

Table 1. Average characteristics of the study sample by sex.

Characteristic	Total 1020	Men 526	Women 494
Age (years)	21.2 ± 3.8	21.3 ± 3.5	21.2 ± 4.1
Weight (kg)	62.1 ± 11.1	66.2 ± 10.7	57.7 ± 9.6
Height (cm)	164.8 ± 8.9	170.8 ± 6.8	158.4 ± 6.1
BMI ($kg \cdot m^{-1}$)	22.8 ± 3.4	22.7 ± 3.4	23.0 ± 3.5
Dominant hand force ($g \cdot cm \cdot s^{-1}$)	35.4 ± 10.5	43.1 ± 8.3	27.3 ± 5.1
VO_2max ($ml./kg./min^{-1}$)	41.4 ± 7.8	45.8 ± 7.2	36.8 ± 5.3

The analysis of anthropometric data revealed significant differences between the sexes in terms of weight and height. This difference of approximately 8.5 kg may be attributed to variations in body composition and muscle mass typically observed between men and women.

In terms of height, the disparity was also substantial. Men were significantly taller, resulting in a difference of 12.4 cm. These differences in height and weight are consistent with general biological trends observed in young adult populations, reflecting the influence of sex-based physiological differences.

Body Mass Index (BMI)

The analysis of body mass index (BMI) revealed minimal differences between men and women. This small difference suggests that although women were shorter and weighed less, their weight-to-height ratios were slightly higher compared to men.

The observed differences in weight and height between men and women align with established patterns in body morphology across sexes. Additionally, the similar BMI values indicate that, despite the differences in weight and height, both men and women maintained overall healthy body proportions.

Table 2 provides a detailed assessment of BMI in the student sample, broken down by sex and university. The table categorizes students into four BMI groups: underweight, normal weight, overweight, and obesity (levels 1, 2, and 3). It also highlights the differences in average BMI within each category.

Table 2. Evaluation of BMI in the sample of students by sex and university.

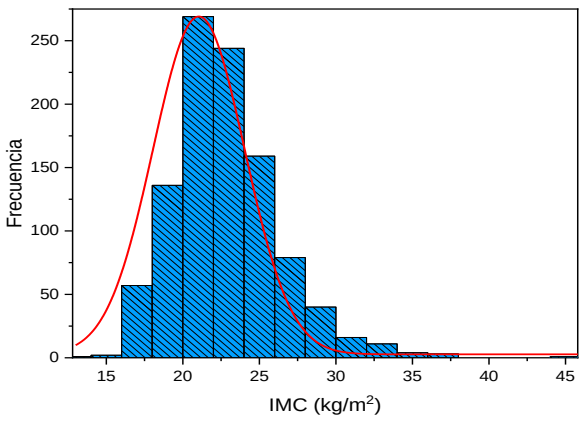
BMI classification	Sex	University					
		CALDAS		CINOC		UNAL	
		N	Average BMI (kg·m^{-1})	N	Average BMI (kg·m^{-1})	N	Average BMI (kg·m^{-1})
Low	Men	11	17.7 ± 0.6	20	17.5 ± 0.6	9	17.2 ± 1.7
	Women	16	17.5 ± 0.8	19	17.5 ± 0.7	2	17.9 ± 0.4
Normal	Men	122	22.1 ± 1.8	179	21.5 ± 1.6	82	22.1 ± 1.9
	Women	126	22.0 ± 1.6	168	21.9 ± 1.6	48	22.0 ± 1.8
Overweight	Men	26	26.8 ± 1.0	30	26.6 ± 1.3	29	27.1 ± 1.4
	Women	36	26.9 ± 1.5	43	26.8 ± 1.4	19	26.8 ± 1.3
Obesity levels 1, 2 and 3	Men	5	31.5 ± 1.4	11	33.6 ± 1.1	2	31.8 ± 1.5
	Women	10	32.2 ± 1.4	7	34.4 ± 1.1	0	-

In the low weight category, the average BMIs for both men and women across the three higher education institutions (HEIs)—Universidad de Caldas (Caldas), CINOC, and National University of Colombia (UNAL)—are quite similar. For the normal weight category, average BMI values are relatively consistent across institutions and genders. In the overweight category, BMI differences between universities and genders are minimal. Men from UNAL have the highest average BMI at 27.1 kg/m^2. For the obesity categories (levels 1, 2, and 3), men from CINOC have the highest average BMI, followed by women from the same university. Notably, no women from UNAL fall into the obesity categories. Additionally, the number of participants in the obesity category is relatively small, which may affect the variability of the results.

Overall, the analysis indicates that average BMI values are consistent across universities for each weight category, with minor variations. The consistency in adequate BMI values suggests that most students maintain a healthy weight regardless of their institution.

Figure 1 presents a histogram showing the distribution of BMI in the study population. The histogram shape suggests a right-skewed distribution, with a higher concentration of data between BMIs of 20 and 24 kg/m^2, which corresponds to the "normal weight" category.

Figure 1. Normal distribution of BMI of the student sample.



The distribution of BMI in the study population reveals a positive skew, indicating that more students have higher-than-average BMIs. This skewness suggests the presence of a notable number of students

in the overweight and obesity categories. This shape indicates a higher concentration of values around the mean and a greater occurrence of extreme values. Although the majority of students maintain a healthy BMI, the presence of significant subgroups with elevated BMIs highlights the importance of implementing health and wellness policies specifically tailored to address these issues in the university community.

Manual Grip Strength (Dinamometry)

Table 3 provides a detailed assessment of the manual grip strength of the dominant hand across the sample. Grip strength, measured in dynamometry units ($g \cdot cm \cdot s^{-1}$), reflects the variations in this capacity among different groups within the study population.

Table 3. Evaluation of the manual grip strength of the dominant hand by sex and university.

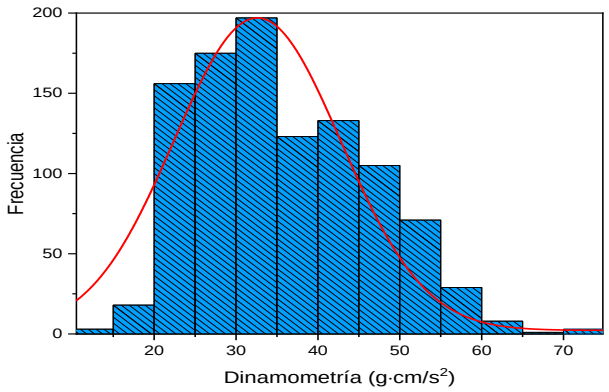
MANUAL GRIP STRENGTH	Sex	Dynamometry ($g \cdot cm \cdot s^{-1}$)		
		CALDAS	CINOC	UNAL
P_3	Men	30.7 ± 4.7	30.2 ± 3.5	26.9 ± 0.9
	Women	19.8 ± 0.6	20.6 ± 1.6	15.4 ± 0.1
10	Men	33.7 ± 3.8	33.1 ± 3.8	28.6 ± 1.3
	Women	22.0 ± 1.2	20.8 ± 1.3	18.6 ± 2.3
25	Men	38.7 ± 3.6	38.9 ± 4.3	32.6 ± 2.0
	Women	24.7 ± 2.0	23.3 ± 1.5	21.5 ± 2.9
P_{50}=	Men	44.3 ± 4.9	43.3 ± 4.9	38.7 ± 4.0
	Women	28.1 ± 2.6	27.0 ± 2.6	24.4 ± 3.1
P_{75}=	Men	50.4 ± 6.0	50.0 ± 6.3	45.6 ± 5.8
	Women	30.7 ± 3.4	30.5 ± 3.6	28.5 ± 3.8
90	Men	54.3 ± 7.0	53.5 ± 7.1	51.5 ± 7.4
	Women	33.3 ± 3.8	33.2 ± 4.1	32.0 ± 4.5
97	Men	59.3 ± 7.7	60.1 ± 7.6	53.4 ± 8.0
	Women	35.9 ± 4.2	38.0 ± 4.9	35.5 ± 5.0

At the 3rd percentile (P3) and 10th percentile (P10), men and women from the University of Caldas and CINOC show similar values, but students at the National University have significantly lower scores. At the 25th and 50th percentiles, there is no significant variability or difference in grip strength between men and women. At the 75th, 90th, and 97th percentiles, men and women from the University of Caldas and CINOC have higher scores than those from UNAL. The distribution of grip strength among men appears more uniform across institutions, although students from UNAL show slightly lower values.

These findings highlight the importance of considering the specific context of each institution when evaluating physical strength and indicate a need for targeted strengthening and training programs to enhance students' physical performance.

Figure 2 presents a histogram illustrating the distribution of grip strength for the dominant hand. The histogram shows the frequency of dynamometry values ($g \cdot cm \cdot s^{-1}$) at various intervals, with an overlaid normal distribution curve (in red) for visual comparison.

Figure 2. Normal distribution of dynamometry of the student sample.



The overall shape of the histogram indicates a distribution that approximates normality, though there are some notable deviations. However, there is a slight positive skew, indicating that some students possess significantly higher grip strength values. This rightward skew may reflect individual differences in physical strength due to factors such as training, genetics, or lifestyle.

Cardiorespiratory Capacity (Vo2max)

Table 4 presents the evaluation of VO2max categorized by sex and higher education institution (HEI), classifying physical condition into four levels: High Performance, High Level, Adequate, and High and Medium Risk.

Table 4. Evaluation of VO2max by sex and university.

Physical condition	Sex	University					
		CALDAS		CINOC		UNAL	
		N	VO_2max (ml./kg./min^{-1})	N	VO_2max (ml./kg./min^{-1})	N	VO_2max (ml./kg./min^{-1})
High performance	Men	4	64.0 ± 1.7	2	62.5 ± 0.0	0	-
	Women	0	-	0	-	0	-
High level	Men	84	51.8 ± 3.7	94	52.2 ± 3.9	64	50.9 ± 3.3
	Women	11	51.4 ± 4.1	5	50.7 ± 3.8	2	49.4 ± 2.1
Adequate	Men	74	40.5 ± 4.7	143	39.9 ± 3.6	58	41.1 ± 4.1
	Women	160	36.9 ± 4.0	205	37.5 ± 3.8	67	36.3 ± 3.7
High and Medium	Men	2	29.6 ± 0.0	1	26.6 ± 0.0	0	-
	Women	17	28.1 ± 1.5	27	27.7 ± 1.6	0	-

For the high-performance group, the men from UCaldas and CINOC showed a high VO2max level. No data are recorded for women in this group across any institution. In the High Level category, VO2max values are fairly consistent across universities for both men and women. In the Adequate group, there is a slight variation in VO2max values between universities. Finally, in the High and Medium Risk group, lower VO2max values are observed, with notable differences between sexes.

Figure 3 illustrates the distribution of VO2max values in the student population. The analysis of the distribution reveals that most values are concentrated in the range of 40 to 50 $ml \cdot min^{-1} \cdot kg^{-1}$. The fitted curve indicates that the data approximate a normal distribution, which is typical for biological measures like VO2max. Higher VO2max values are associated with better aerobic and cardiovascular capacity.

Figure 3. Normal distribution of OV2max in the sample of students.

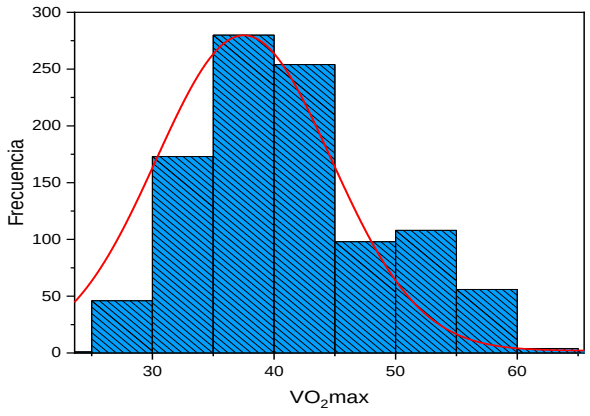
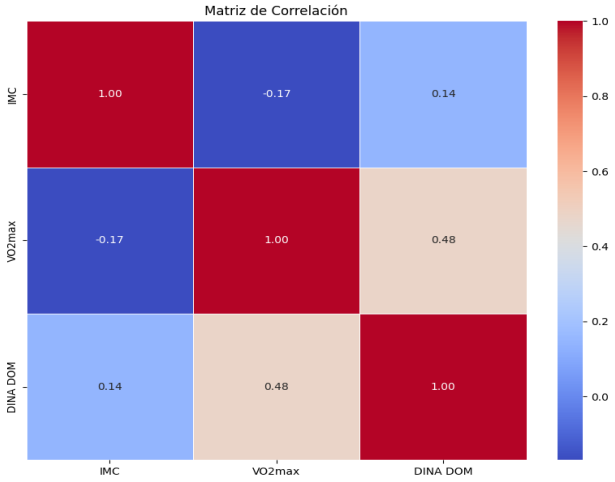


Figure 4 provides a detailed visual representation in the form of a heat map, designed to elucidate the complex relationships among three fundamental variables: Body Mass Index (BMI), VO2max, and dominant hand dynamometry (DINA_DOM).

The first relationship examined is between BMI and VO2max, with a correlation coefficient of -0.17, indicating a weak negative relationship. Next, the correlation between BMI and grip strength is analyzed,

represented by a coefficient of 0.14. This indicates a weak positive relationship. Finally, the correlation between VO2max and grip strength is examined, yielding a coefficient of 0.48. This denotes a moderate positive correlation, suggesting that as VO2max increases, grip strength also tends to increase.

Figure 4. Correlation matrix of the study variables calculated using the Spearman correlation coefficient.



Discussion

The variables defined in this study provide a comprehensive view of factors influencing the risk of acquiring non-communicable diseases (NCDs) among tertiary education students. The following discussion elaborates on the key findings and potential areas for intervention.

Body Composition

The prevalence of low weight among students across the three institutions is approximately 10% for both sexes. While this percentage is relatively low, it warrants attention and proactive intervention. Low weight can be associated with a range of health risks, including osteoporosis, anemia, impaired immune function, and poor eating habits, particularly in university students (Saintila et al., 2024). Addressing low weight is crucial to prevent the development of these health issues and to ensure that students maintain a healthy weight. Initiatives should focus on improving nutritional intake and promoting healthy lifestyle habits.

Adequate weight is the most common category among students, with approximately 60% of both men and women falling into this range. This finding aligns with previous studies (Saintila et al., 2024; WHO, 2024) and reflects a generally positive health status. However, it is important to remain vigilant and implement strategies to prevent the progression to overweight and obesity. Maintaining a healthy weight within the normal BMI range is vital for reducing the risk of NCDs, such as cardiovascular diseases, stroke, type II diabetes, and certain cancers (Saintila et al., 2024). Regular physical activity and balanced diets are essential components of a healthy lifestyle that can help individuals sustain a healthy weight (WHO, 2022; Martínez et al., 2021).

The prevalence of overweight is similar at the Universidad de Caldas, UNAL and CINOC, this suggests a need for focused interventions to address overweight, a growing public health issue affecting university students (Saintila et al., 2024; Jiang et al., 2022). Effective strategies should promote healthy lifestyles, weight management, and preventive measures to mitigate the risk of NCDs.

Obesity rates are the lowest among students, with values around 5% for both men and women, consistent with other studies (Seyam, 2025; Lamadrid-Castro et al., 2023). Despite being statistically small, this group requires attention due to the serious health implications of obesity. Obesity is not only a significant public health problem due to its immediate effects but also a risk factor for the development of long-term NCDs, which are leading causes of death worldwide, representing 71% of deaths (Seyam,

2025; Zhou et al., 2024; Rodríguez-Pérez et al., 2023; WHO, 2023). Obesity can lead to severe health conditions such as heart disease, stroke, diabetes, and some types of cancer.

Dinamometry

The grip strength measurements among the university students evaluated reveal considerable variability, with levels ranging from normal to high, and conversely, women generally show significantly lower grip strength across all evaluated universities.

These findings are consistent with those of Carrillo et al (2025), who reported significantly higher mean grip strength in men (37.1 ± 8.3 kg) compared to women (24.2 ± 8.1 kg) ($p < 0.001$). In their study, grip strength increased with age for both men and women, but men exhibited higher and more consistent values across all age groups. Similar results were observed in some studies of healthy university students, where the average grip strength (44.77 ± 6.6 kg for men and 27.70 ± 4.3 kg for women, and 38,36 ± 7,86 kg, 25,44 ± 5,24 kg, respectively (Rodrigues & Ceballos, 2024; Montalcini et al., 2013).

Regarding the relationship between grip strength and Body Mass Index (BMI), a weak positive correlation was found. This suggests a slight association between higher grip strength and higher BMI, echoing findings to others studies indicating that grip strength is related to muscle mass, height, and physical activity levels (Rodrigues & Ceballos, 2024; Rodríguez & Velasco, 2019).

In older adulthood, decreases in muscle mass and strength are well-documented (Suarez et al., 2025; Prado, 2022; An & Kim, 2019). Grip strength (FPM) is a strong predictor of functional limitations in later life. A decline in grip strength is linked to increased risk of disability and functional limitations, while a robust baseline of muscle strength in adulthood can provide a greater margin of safety against disability in later years (Suarez et al., 2025; López-Bueno, et al., 2022). Additionally, low grip strength has been associated with the development of NCDs, such as coronary heart disease and stroke, indicating that muscle strength might be an important predictor of these conditions (López-Bueno et al., 2022; Soysal et al., 2021; Silventoinen et al., 2009).

The correlation between VO2max and grip strength, with a coefficient of 0.48, indicates a moderate positive relationship. As VO2max increases, grip strength also tends to increase, suggesting a correlation between muscle strength and aerobic capacity (Maria et al., 2025; Ventura-Cruz et al., 2025). This relationship aligns with findings from other studies. For instance, Buttar et al (2025) found an independent association between VO2max and grip strength in older adults. Similarly, Ajepe et al (2022) reported a significant moderate correlation ($r = 0.40$, $p = 0.001$) between VO2max and grip strength in healthy young adults. These results underscore the interrelation between physical strength, aerobic capacity, and physical activity levels.

Cardio-Respiratory Fitness

Cardio-respiratory fitness is defined as the ability of the circulatory and respiratory systems to supply sufficient oxygen to the muscles and other systems, with cardiac function playing a crucial role. This capacity is essential in reducing the risk of non-communicable diseases (NCDs) such as cardiovascular diseases, stroke, type II diabetes, and obesity (Posso et al., 2026; Lang et al., 2024).

The majority of the students evaluated have VO2max values above 36.9 ml/kg/min, which is considered satisfactory. These values fall within the "Adequate" and "High Performance" categories (Corral-Pernía & Del-Catillo, 2010; García-Manso et al., 1996), indicating that most students possess an aerobic capacity that is appropriate for their age and gender.

This suggests that if students maintain these high levels of cardio-respiratory fitness through regular physical activity, exercise, and sports (Carrillo et al., 2025; Lara et al., 2023; Negret, 2016), they could lower their risk factors for NCDs (Posso et al., 2026). Additionally, this could contribute to reducing BMI, combating sedentary lifestyles, and fostering healthy habits (Escandón et al., 2023; Visseren et al., 2021; Williamson et al., 2021).

Despite these positive results, attention must be paid to the "Medium and High Risk" group. Although this group is relatively small, its members are at risk for developing high levels of overweight and obesity, with all the associated health implications. The results suggest that these students should be monitored closely as they may be at higher risk of acquiring NCDs (Escandón et al., 2023; Williamson et al., 2021).

Furthermore, the inverse correlation between cardiorespiratory capacity and BMI suggests that a higher BMI is associated with lower cardio-respiratory fitness. This indicates a need for targeted interventions that encourage physical activity and exercise among students with higher BMI levels (Posso et al., 2026; Potosí-Moya et al., 2024; Martins et al., 2023).

Conversely, the positive relationship between VO2max and grip strength suggests that improvements in cardio-respiratory fitness are associated with enhanced grip strength, reinforcing the importance of maintaining good physical condition as a strategy to reduce the risk of NCDs (Ochoa et al., 2026; Lin et al., 2025; Ajepe et al., 2022).

Conclusions

This analysis provides a comprehensive overview of the physical condition of the students in the sample and offers valuable insights for designing programs aimed at promoting physical activity, exercise, and sports. These programs should focus on interventions that encourage and develop healthy lifestyles and habits, incorporating regular physical and anthropometric assessments to help reduce the risk of acquiring non-communicable diseases (NCDs).

The results suggest that a significant percentage of tertiary education students engage in regular physical and sports activities, leading to physical conditions that exceed adequate levels. These findings align with the World Health Organization (WHO) guidelines for reducing physical inactivity and sedentary behaviors, which are critical in preventing NCDs such as hypercholesterolemia, hypertension, diabetes mellitus, and obesity (Parvin et al., 2022).

For women, the more pronounced differences across universities suggest that environmental and socioeconomic factors may influence grip strength; this could be due to differences in physical activity, training, or nutritional factors.

The variations observed in extreme weight categories highlight the importance of considering specific contexts when assessing and addressing health and nutrition issues in student populations.

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References

Ajepe, O., Mgbemena, N., Okafor, U., Ehuwa, O., Okeke, C., Osundiya, O., Oyedemi, Y., & Ezeugwa, Ch. (2022). Relationship between estimated VO2max and hand grip strength in healthy Nigerian young adults. *Internet Journal of Practice and Related Health Sciences.* 1; Art. 17. https://doi.org/10.46743/1540-580X/2022.2079

An, K. O., & Kim, J. (2019). Associations between Handgrip Strength with Adverse Cardiometabolic Health among Representative Korean Adults. *Int J Environ Res Public Health*. 17 (1):269. https://doi.org/10.3390/ijerph17010269

Araújo, C. G. S., Kunutsor, S. K., Eijsvogels, T. M. H., Myers, J., Laukkanen, J. A., Hamar, D., Niebauer, J., Bhattacharjee, A., de Souza E Silva, C. G., Franca, J. F., & Castro, C. L. B. (2025). Muscle Power

Versus Strength as a Predictor of Mortality in Middle-Aged and Older Men and Women. *Mayo Clinic proceedings*, *100*(8), 1319–1331. https://doi.org/10.1016/j.mayocp.2025.02.015

Beltrán Carrillo, V. J., Sierra, A. C., Jiménez Loaisa, A., González-Cutre, D., Martínez Galindo, C., & Cervelló, E. (2017). Diferencias según género en el tiempo empleado por adolescentes en actividad sedentaria y actividad física en diferentes segmentos horarios del día. *Retos, 31*, 3-7. https://doi.org/10.47197/retos.v0i31.36207

Booth, F. W., Roberts, C. K., Thyfault, J. P., Ruegsegger, G. N., & Toedebusch, R. G. (2017). Role of Inactivity in Chronic Diseases: Evolutionary Insight and Pathophysiological Mechanisms. *Physiological reviews*, 97(4), 1351–1402. https://doi.org/10.1152/physrev.00019.2016

Brito, S., Basualto, L., & Reyes, L. (2019). Social/Educational Inclusion, in Higher Education Code. *Scielo*, 13. http://dx.doi.org/10.4067/S0718-73782019000200157

Buttar, K. K., Kacker, S., & Saboo, N. (2025). The association between components of health-related physical fitness in healthy adults: A cross-sectional study. *Journal of family medicine and primary care*, 14(9), 4021–4026. https://doi.org/10.4103/jfmpc.jfmpc_328_25

Carrillo-Arango, H. A., Atencio-Osorio, M. A., Martínez-García, D. I., Ossa-Tabares, K. S., Dominguez, L. L., Zapata, J. S., ... & Leyva-Cuero, L. M. (2025). Factores de riesgo asociados a enfermedad cardiovascular en estudiantes universitarios: Factores asociados a riesgo cardiovascular en universitarios. *Retos*,70, 243–257. https://doi.org/10.47197/retos.v70.106949

Cebrian-Ponce, A., Serafini, S., Petri, C., Carrasco-Marginet, M., Izzicupo, P., & Mascherini, G. (2024). Somatotype and bioelectrical impedance vector analysis of Italian CrossFit® practitioners. *Heliyon*, 10 (2024) e29139. https://doi.org/10.1016/j.heliyon.2024.e29139.

Chacón-Borrego, F., Corral-Pernía, J. A., & Castañeda Vázquez, C. (2020). Condición física en jóvenes y su relación con la actividad física escolar y extraescolar. Revista Interuniversitaria De Formación Del Profesorado. *Continuación De La Antigua Revista De Escuelas Normales*, 34(1). https://doi.org/10.47553/rifop.v34i1.77077

Corral-Pernía, J. A., & Del-Catillo A. Óscar. (2010). The assessment of VO2 max. and its relationship with cardiovascular risk as a means of teaching-learning. *Cuadernos de Psicología del Deporte*, 10(2). Disponible en: https://revistas.um.es/cpd/article/view/111231

Escandón, S., Andrade, S., Molina-Cando, M. J., Ramón, F., Zamora, Z., & Ochoa-Avilés, A. (2023). Percentile of physical condition in children and adolescents from Cuenca - Ecuador: alpha-fit battery. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte*. 23 - 92 191-210. https://pure.ups.edu.ec/es/publications/percentile-of-physical-condition-in-children-and-adolescents-from/)

Estrada-Araoz, E. G., Churayra-Chura, J. E., Quispe-Loaiza, M. Y., Mamani-Velasquez, D. E., Salas-Luza, C. K., Ventura-Carreón, D. D., Paredes-Valverde, Y., & Quispe-Herrera, R. (2025). Predictores de la satisfacción con la vida entre estudiantes universitarios peruanos: una mirada desde la dimensión corporal y motivacional. Retos, 71, 1-12. https://doi.org/10.47197/retos.v71.116076

Galán-Arroyo, C., Mendoza-Muñoz, D. M., & Rojo-Ramos, J. (2024). La aptitud física, indicador de un desarrollo saludable en el preadolescente. *Retos*, *52*, 447-456. https://doi.org/10.47197/retos.v52.99772

García-Manso, J. M.; Navarro-Valdivieso, M. & Ruiz-Caballero, J. A. (1996). *Tests for the assessment of motor ability in sport. Evaluación de la condición física*. Madrid: Gymnos.

García, G. C., & Secchi, J. D. (2014). 20-meter Test Course Navette with one-minute stages. An original idea that has been around for 30 years. *Apunts Med Esport*. 49(183):93-103. https://doi.org/10.1016/j.apunts.2014.06.001

Gea-García, G. M., González-Gálvez, N., Espeso-García, A., Marcos-Pardo, P. J., González-Fernández, F. T., & Martínez-Aranda, L. M. (2020). Relationship Between the Practice of Physical Activity and Physical Fitness in Physical Education Students: The Integrated Regulation as a Mediating Variable. *Frontiers in psychology*, *11*, 1910. https://doi.org/10.3389/fpsyg.2020.01910

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet. Child & adolescent health*, 4(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Hernandez-Sampieri, R., Fernandez-Collado, C., Baptista-Lucio, P. (2020). Research Methodology. 4 ed. McGraw-Hill, 1990.

Hoeger, W. (1996) *Fitness and general well-being*. Colorado, Morton Publishing Company.

IHME. Institute for Health Metrics and Evaluation (2019). *Global Burden of Disease Study (GBDS*). Global Burden of Disease Collaborative Network. Available at: https://www.healthdata.org/research-analysis/gbd.

Jiang, K., Zhang, Z., Fullington, L., Huang, T., Kaliszewski, C., Wei, J., & Wu, S. (2022). Prevalence and associated factors of overweight and obesity among university students: A meta-analysis. *Nutrients,* 22(14). https://doi.org/10.3390/nu14224911

Lamadrid-Castro, S., Arana-Baquero, W de J., Cuello-Cerchiaro, E. J., Suárez-Carrillo, E. B., & Peñuela-Epalza, M. E. (2023). Estilo de vida, Sobrepeso y obesidad en estudiantes de ciencias de la salud durante el confinamiento por COVID-19 en Barranquilla (Colombia). *Revista Salud Uninorte* , 39 (2), 565-583. Publicación electrónica del 21 de marzo de 2024. https://doi.org/10.14482/sun.39.02.612.986

Lara-Rodríguez, L.M., Juarez-Lozano, R., & Medrano-Donlucas, G. (2023). Physical culture in the university environment: Trend of sports and physical activity options from Mexican students in health sciences. *IE. Revista de Investigación Educativa de la Rediech*, 4 (14) e1608. https://doi.org/10.33010/ie_rie_rediech.v14i0.1608

Lang, J. J., Prince, S. A., Merucci, K., Cadenas-Sanchez, C., Chaput, J., Fraser, B. J., Manyanga, T., McGrath, R., Ortega, F. B., Singh, B., & Tomkinson, G. R. (2024). Cardiorespiratory fitness is a strong and consistent predictor of morbidity and mortality among adults: an overview of meta-analyses representing over 20.9 million observations from 199 unique cohort studies. *British Journal of Sports Medicine*, 58(10), 556-566. https://doi.org/10.1136/bjsports-2023-107849

Lin, G., Chen, J., Yan, R., Deng, B., Song, W., Guan, B., & Sun, J. (2025). Effects of maturation stage on physical fitness in youth male team sports players after plyometric training: A systematic review and meta-analysis. *Sports Medicine – Open*, 11(1). https://doi.org/10.1186/s40798-025-00907-9

López-Bueno, R., Andersen, L. L., Koyanagi, A., Núñez-Cortés, R., Calatayud, J., Casaña, J., & Del Pozo Cruz, B. (2022). Thresholds of handgrip strength for all-cause, cancer, and cardiovascular mortality: A systematic review with dose-response meta-analysis. *Ageing research reviews*, 82, 101778. https://doi.org/10.1016/j.arr.2022.101778

Lopez-Jaramillo, P., Lopez-Lopez, J. P., Tole, M. C., & Cohen, D. D. (2022). Muscular Strength in Risk Factors for Cardiovascular Disease and Mortality: A Narrative Review. *Anatolian journal of cardiology*, *26*(8), 598–607. https://doi.org/10.5152/AnatolJCardiol.2022.1586

Maria, S.A., Nicolae, O. M., Nicola, M., Szekely, A. S., Sorin, S., Dorina, I., Hervás-Gómez, C., Cornelia, P., Florina, G. E., & Teodor, G. V (2025). jump Rope Training Improves Muscular Strength and Cardiovascular Fitness in University Students: A Controlled Educational Intervention. *Sports*, 13 (9), 307. https://doi.org/10.3390/sports13090307

Martins, H. A., Barbosa, J. G., Seffrin, A., Vivan, L., Souza, V. R. de A., de Lira, C. A. B., Weiss, K., Knechtle, B., & Andrade, M. S. (2023). Sex differences in maximal oxygen uptake adjusted for skeletal muscle mass in amateur endurance athletes: A cross-sectional study. *Healthcare*, 11(11), 1502. https://doi.org/10.3390/healthcare11101502

Martínez, V. R., Sandoval-Copado, J. R., & Aranzana-Juarros, M. (2021). Acceso a la alimentación y hábitos alimentarios de jóvenes universitarios, Estado de México. *RESPYN Revista Salud Pública Y Nutrición*, *20* (3), 36–45. https://doi.org/10.29105/respyn20.3-5

MEN (2024). The National System of Tertiary Education. Cundinamarca-Bogotá. Available at: https://www.mineducacion.gov.co/portal/decadas/355208:The-Tertiary-Education-National-System.

Montalcini, T., Migliaccio, V., Yvelise, F., Rotundo, S., Mazza, E., Liberato, A., & Pujia, A. (2013). Reference values for handgrip strength in young people of both sexes. *Endocrine*. 43 (2):342-5. https://doi.org/10.1007/s12020-012-9733-9.

Negret, J. (2016). Citizen training, physical culture and sport: strategy for quality training, *Revista Cubana de Educación Superior*, (1), 4-17. http://scielo.sld.cu/pdf/rces/v35n1/rces01116.pdf

Ochoa-Granda, E. G., Piedra-Espejo, J. I., Sanmartín-Cruz, H. D., Quezada-Vargas, R. L., & Herrera-Piedra, F. A. (2026). Physical Condition, Motor Competence and Cardiometabolic Health in Childhood: Theoretical Bases for Early Prevention, *Revista Educación y Ciencia*, 7(2), 132-142. https://doi.org/10.5281/zenodo.18497337

PAHO. Pan American Health Organization (2022). *Enfermedades No Transmisibles, 2022.* Available at: https://www.paho.org/es/temas/enfermedades-no-transmisibles#:~:text=El%20consumo%20de%20tabaco%2C%20la,la%20respuesta%20a%20las%20ENT

Parada-Sánchez, H. D., & Gálvez-Pardo, Á, Y. (2022). Body composition and eating habits in university students. *Body, culture and movement*, *12*(2). https://doi.org/10.15332/2422474X.7882.

Pasdar, Y., Darbandi, M., Mirtaher, E., Rezaeian, S., Najafi, F., & Hamzeh, B. (2019). Associations between Muscle Strength with Different Measures of Obesity and Lipid Profiles in Men and Women: Results from RaNCD Cohort Study. *Clinical nutrition research*, *8*(2), 148–158. https://doi.org/10.7762/cnr.2019.8.2.148

Parvin, P., Amiri, P., Masihay-Akbar, H., Khalafehnilsaz, M., Cheraghi, L., Ghanbarian, A., & Azizi, F. (2022). A pragmatic multi-setting lifestyle intervention to improve leisure-time physical activity from adolescence to young adulthood: the vital role of sex and intervention onset time. *Int J Behav Nutr Phys Act*, 19 (65). https://doi.org/10.1186/s12966-022-01301-4

Peña-Ibagon, J. C., Rodriguez Becerra, D., Rincon-Vasqueza, F. J., & Castillo-Daza, C. A. (2021). Relación entre los niveles de actividad física y la condición física autopercibida en una muestra de estudiantes universitarios en Bogotá, Colombia. *Fisioterapia* 43, 340 – 346. https://doi.org/10.1016/j.ft.2021.03.005

Pico-Fonseca, S., Quiroz-Mora, C., Hernández-Carrillo, M., Arroyave-Rosero, G., Idrobo-Herrera, I., Burbano-Cadavid, L., Rojas-Padilla, I., & Piñeros-Suárez, A. (2021). Relationship between food consumption pattern and body composition of university students: cross-sectional study. *Hospital Nutrition*, 38(1), 100-108. Epub April 26, 2021. http://dx.doi.org/10.20960/nh.03132 (https://www.nutricionhospitalaria.org/articles/03132/show)

Posso-Yépez, M., Flores-Bosmediano, E., BuitrónJácome, P., Osejos, E., Posso-Astudillo, M., & Realpe-Zambrano, Z. E. (2026). Índice de masa corporal y consumo máximo de oxígeno: análisis correlacional y diferencias según sexo y edad de estudiantes universitarios. *Retos*, 76, 754-768. https://doi.org/10.47197/retos.v76.118265

Potosí-Moya, V., Paredes-Gómez, R., & Durango-Sánchez, X. (2024). HIIT y su influencia sobre el VO_2max en estudiantes de fisioterapia. *Retos*, 54, 616–624. https://doi.org/10.47197/retos.v54.104333

Rodrigues-Bezerra, D., & Ceballos-Bernal, E. A. (2024). Handgrip in university students in Bogotá Colombia. *Ciencias de la actividad física (Talca),* 25(2), 4. Epub 27 de agosto de 2024. https://dx.doi.org/10.29035/rcaf.25.2.4

Rodríguez-Cuadra, R., & Velasco-Ramirez, S. F. (2019). Hand grip strength and physical activity level in university students from Uruapan Michoacán, Mexico. *Clinical Nutrition and Hospital Dietetics*, 39(3), 109-114. https://doi.org/10.12873/393rodriguez

Rodríguez-Pérez, C., Carreño-Ruíz, S. D., Ortiz-Ojeda, R. F., & Avalos-Lázaro, A. A. (2023). Análisis de la relación entre el índice de masa corporal y la somnolencia diurna en universitarios mexicanos. *Revista Española de Nutrición Humana y Dietética*, 27(3), 205-212. Epub 17 de mayo de 2024. https://dx.doi.org/10.14306/renhyd.27.3.1918

Rosa-Guillamón, A. (2019). Analysis of the relationship between health, physical exercise and physical fitness in schoolschildren and adolescents, *Revista Ciencias de la Actividad Física*, 20 (1), pp. 1-15. https://doi.org/10.29035/rcaf.20.1.1 (https://www.redalyc.org/journal/5256/525661507008/html/)

Ruiz Castellanos, E. J., Sánchez Rojas, I. A., Rincon Herrera, A. D., Sánchez Hernández, N. D., Mendoza Romero, D., & Lozano Rueda, S. (2021). Niveles de actividad física en adolescentes de Colombia. Revista Iberoamericana De Ciencias De La Actividad Física Y El Deporte, 10(3), 78-98. https://doi.org/10.24310/riccafd.2021.v10i3.12533

Saintila, J., Calizaya-Milla, Y. E., Carranza-Cubas, S. P., Serpa-Barrientos, A., Oblitas-Guerrero, S. M., & Ramos-Vera, C. (2024). Body mass index and healthy lifestyle practices among Peruvian university students: a comparative study among academic discipline. *Frontiers in nutrition*, 11, 1361394. https://doi.org/10.3389/fnut.2024.1361394

Scarfó, F., (2015). Human Rights Education and tertiary education: a mutual and multiplying need. *I meet again. Analysis of University Problems*, (70), 25-46. Available at: https://www.redalyc.org/pdf/340/34046812003.pdf.

Seyam, M. K. (2025). Prevalence of obesity and associated risk factors among university students using the newly developed Student Lifestyle and Obesity Risk Questionnaire (SLORQ): a cross-sectional study. *PeerJ* 13:e19556 http://doi.org/10.7717/peerj.19556

Soysal, P., Hurst, C., Demurtas, J., Firth, J., Howden, R., Yang, L., Tully, M. A., Koyanagi, A., Ilie, P. C., López-Sánchez, G. F., Schwingshackl, L., Veronese, N., & Smith, L. (2021). Handgrip strength and health outcomes: Umbrella review of systematic reviews with meta-analyses of observational studies. *Journal of sport and health science*, 10(3), 290–295. https://doi.org/10.1016/j.jshs.2020.06.009

Suárez León, M. V., Ramos-Bermúdez, S., Ramírez-García, C. M., García-García, A. M., & Castrillón-Rendón, B. S. (2025). Prevalencia de sarcopenia en estudiantes universitarios colombianos mediante fuerza de prensión manual y perímetro de pantorrilla corregido por IMC. *Retos,* 62, 862-871. https://doi.org/10.47197/retos.v62.110131

Ventura-Cruz, V. A., Pacheco-Ferreira, L. M., Torres Polanco, Z., Luzón-Sala, H., & Ventura De León, R. (2025). Análisis del estado nutricional y su incidencia en la fuerza prensil de estudiantes del nivel secundario. *Revista Multidisciplinaria Voces de América y el Caribe*, 2(2), 288-305. https://doi.org/10.69821/REMUVAC.v2i2.233

Villalobos, C., Kuzmanic, D., Valenzuela, J. P., & Quaresma, M. L. (2022). Social Perceptions of Elite Higher Education Students: A Chilean Case Study. *Scielo*, 31. http://dx.doi.org/10.7764/psykhe.2020.22549

Visseren, F. L. J., MacH, F., Smulders, Y. M., Carballo, D., Koskinas, K. C., Bäck, M., Benetos, A., Biffi, A., Boavida, J. M., Capodanno, D., Cosyns, B., Crawford, C., Davos, C. H., Desormais, I., DI Angelantonio, E., Franco, O. H., Halvorsen, S., Hobbs, F. D. R., Hollander, M., … & Williams, B. (2021). 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *European Heart Journal,* 42(34), 3227-3337. https://doi.org/10.1093/eurheartj/ehab484

WHO. Organización Mundial de la Salud. (2024). Malnutrición. Available at: https://www.who.int/es/news-room/fact-sheets/detail/malnutrition

WHO. World Health Organization. (2023). *Obesidad y sobrepeso*. Editor, Bulletin of the World Health Organization, Available at: https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight

WHO. Organización Mundial de la Salud. (2022). *Enfermedades no transmisibles*, *2022.* Available at: https://www.who.int/es/news-room/fact-sheets/detail/noncommunicable-diseases.

WHO. Organización Mundial de la Salud. (2017). *Who publishes a new edition of the report on monitoring progress on non-communicable diseases*. Available at: https://www.who.int/es/news/item/18-09-2017-who-launches-new-ncds-progress-monitor

Williamson, T., Moran, C., Chirico, D., Arena, R., Ozemek, C., Aggarwal, S., Campbell, T., & Laddu, D. (2021). Cancer and cardiovascular disease: The impact of cardiac rehabilitation and cardiorespiratory fitness on survival. *International journal of cardiology*, 343, 139–145. https://doi.org/10.1016/j.ijcard.2021.09.004

Zhou, X. D., Chen, Q. F., Yang, W., Zuluaga, M., Targher, G., Byrne, C. D., Valenti, L., Luo, F., Katsouras, C. S., Thaher, O., Misra, A., Ataya, K., Oviedo, R. J., Pik-Shan Kong, A., Alswat, K., Lonardo, A., Wong, Y. J., Abu-Abeid, A., Al Momani, H., Ali, A., … Zheng, M. H. (2024). Burden of disease attributable to high body mass index: an analysis of data from the Global Burden of Disease Study 2021. *EClinicalMedicine*, *76*, 102848. https://doi.org/10.1016/j.eclinm.2024.102848

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