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ANTHROPOMETRIC PARAMETERS REGARDING THE NUTRITIONAL STATUS OF SCHOOLCHILDREN

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ABSTRACT- Objective. This study assesses the anthropometric parameters concerning the nutritional status of and establishes the prevalence of excessive weight, obesity, and malnutrition among schoolchildren in an educational institution on Colombia's northern coast. **Materials and methods.** A quantitative correlational research was conducted. The sample included 556 children aged between 6 and 11 years (310 boys and 246 girls). Their weight, height, BMI, and nutritional status were evaluated, and the BMI/age variable (Z-score)was studied to determine the nutritional categories of underweight, normal, and excess weight (overweight and obese) through a descriptive analysis and analysis of variance (ANOVA) using an unbalanced factorial design. **Results.** Thinness and obesity cases were reported, with 21.43% (119/556) of the students experiencing some kind of nutritional disorder. Although no statistically significant differences were observed between the gender factor levels, ANOVA showed that male students tend to move farther from the expectedZ-scores. **Conclusion:** The average Z-score of young students is usually closer to the expected score, whereas that of older students is farthest from expectation, in addition to showing greater variability between measures.

Keywords: Anthropometry, nutritional status, obesity, overweight

I. INTRODUCTION

The World Health Organization (WHO) estimates that at least 41 million children worldwide are overweight or obese, 155 million suffer from stunted growth, and 52 million are affected by emaciation (rapid pathological weight loss) (1). As a result, the prevalence of non-communicable diseases has increased to 74.2%, particularly in countries belonging to Latin America and the Caribbean. In 2016, these diseases caused three of every four deaths of the total 3.8 million deaths in this region. Moreover, the number ofundernutrition cases increased notably, accompanied by stunted growth, underweight, and emaciation (2). The FAO and the WHO suggest that the risk factors for chronic diseases in the adult population originate in the early stages of life (3) (4).

Anthropometry is considered one of the essential techniques to diagnose the percentage of body fat and degree of obesity across different populations within a community, given that it requires less time and the materials required are affordable (5). Anthropometric analysis is a tool that allows for body measurement by

determining the height and weight(6). It helps characterize population groups; assess their nutritional status; and measure their physical growth, body proportion, and shape across the stages of human development (7).

Height and weight are globally accepted parameters to assess the nutritional status of different groups and establish the prevalence of overweight individuals. Colombia shows a strong relationship between being overweight, obese, and physical inactive and the risk of developing Type 2 Diabetes Mellitus (T2DM) among adults from Barranquilla (8).

The study variables include nutritional status, which is defined as the balance between energy consumption and the nutrients required by the human body for proper functioning. This impacts the individual's welfare, which largely depends on the interaction between diet; health-related factors; and the physical, social, cultural, and economic environment (9, 10). This study used the Z-score, a quality indicator for anthropometric measurements applied to assess the baseline/standard deviation measurement of the reference population and reveal the standard deviations (SD) moving away from the average value.

Eating habits are the individual and collective behavior with regard to food consumption (11, 12) and areunderstood as repeated behavior at the individual and collective levels concerning what, when, how, and why food is eaten. Habits mostly involve three agents: family,mass media, and school (13).

In addition, malnutrition represents a pathological condition that may be caused by a decrease in nutrient intake or an alteration in the organism's use of nutrients. Malnutrition increases the risk of morbidity and mortality rates due to food insecurity (14) and is understood as the partial or total interrupted access to food (15). In case of infants, this is the result of presence and interaction of the social determinants of health (16, 17).

Undernutrition and excessive weight/obesity make up the so-called "double burden," as they lead to negative consequences in physical growth and intellectual development, in addition to increasing the risk of suffering from non-communicable chronic diseases (NCCDs) (18). Undernutrition is a disease affecting the organic and psychological functions of individuals as well as their overall health status, which will be impacted throughout their life (19). As indicated by the WHO, based onthe number of deaths, excessive weight and obesity are the second highest risk factor for developing NCCDs, following hypertension. Colombia has a prevalence of excessive weight (37.7%) and obesity (18.7%) cases among young and adult populations (20), and diet is the key external determinant for an individual's growth and development during childhood (21).

This article presents the results of a study analyzing the anthropometric parameters regarding nutritional status by assessing variables such as gender, weight, size, and BMI of schoolchildren aged 6 to 11 years in an official educational institution located on Colombia's northern coast. To this end, nutritional measurements of 556 students were assessed, involving a descriptive analysis of the Z-score as a quality indicator for anthropometric data and an analysis of variance (ANOVA) under an unbalanced factorial design for this variable.

II. MATERIALS AND METHODS

Type of study: A quantitative, correlational research study, including a purposive sample comprising 556 students from the *Institución Educativa de la Costa Caribe (*Colombian Educational Institution of the Caribbean Coast*)*attending school in the morning and afternoon shifts, was conducted. A registered nurse, a nutritionist, and a nursing student were responsible for data collection, taking into account the following inclusion criteria: boys and girls enrolled in the educational institution were aged between 6 and 11 years in 2019. Children whose parents or guardiansdid not give participation consent were excluded. The tools used for weight and height measurement were a height rod and a scale.

Height and body composition equipment and instruments were implemented to conduct the anthropometric evaluation: a portable scale to track weight (kg) and a portable Seca stadiometer to record height (cm), with a centimeter and millimeter graduation range from 20 to 205 cm,divided by 1 mm. The scale on the side allows

height to be checked during the measurement, thus ensuring result accuracy for up to a 205-cm stature. The portable digital scale has a limit of 300 kg/660 lb, divided into 50 g/0.1 lb, dimensions (WxHxD) of 440x2,400x470 mm/17.3x94.5x18.5 inches and a platform (WxHxD). The parameters set by the Ministry of Social Protection'sguidelines for anthropometric measurements were followed when weight and height measurements were taken (22).

The material adopted by the Ministry of Health and Social Protection by Resolution No. 00002465 of June 2016, the Child Growth Standards published in 2006–2007 by the WHO,and the cut-off points for the anthropometric classification of the nutritional status of children and adolescents under the age of 18 years, as established in Standard (23), were used for classification purposes.

Table 1. Classification with regard to Body Mass Index in children aged 5 to 17 years relative to the standard deviation (SD) use recommended by the WHO (23):

Classification	Definition
Eutrophic	SD 0 from the BMI median (0SD).
Overweight	1 SD from the BMI median (+1 SD)
Obesity	2 SD from the BMI median (+2 SD)
Severe obesity	3 SD from the BMI median (+3 SD)
At risk of thinness	>−2 to<−1 SD
Thinness	<−2 SD.

Source: Resolution No. 00002465 of June 2016

Procedure: For information collection, students were approached during their regular lessons, conducting anthropometric assessments and conducting a survey on their consumption habits.

Statistical analysis: The Z-score was assessed through central tendency and dispersion descriptive statistical techniques such as the average, SD, coefficient of variation, and frequency table. In addition, the measurements of bias and shape, such as Standardized Bias and Standardized Kurtosis, were calculated. The descriptive analysis was conducted on the "Z-score" variable. First, the various central tendency and dispersion descriptive statistics were estimated, with values showing that the average $\bar{y}$ = 0.0703571, which is rather close to the ideal values for the variable ($\bar{y}$ = 0).Scatter plots and box-and-whisker plots, histograms, and normal probability plots were also obtained and analyzed. The Design of Experiments analysis (DOE) was carried out to observe the influence of grade, gender, age, weight, and height on the Z-score value. In this regard, levels were set for each factor, the ANOVAtable was obtained, and the P-values were calculated. The study also included checking the normality of the Z-score response variable and generating least significant difference (LSD) average charts.

Ethical considerations: The requirements provided by the scientific, technical, and administrative standards applicable to Simón Bolívar University's internal ethical regulation No. 00002 of March 15, 2011 (24) have been strictly met by this study. It is considered a minimal risk research study as the procedures implemented to record data included the schoolchildren's weight and height measurement (25).

Informed consent and/or approval in accordance with current legislation (Resolution 8430 of 1993). A privacy statement was provided by each researcher.

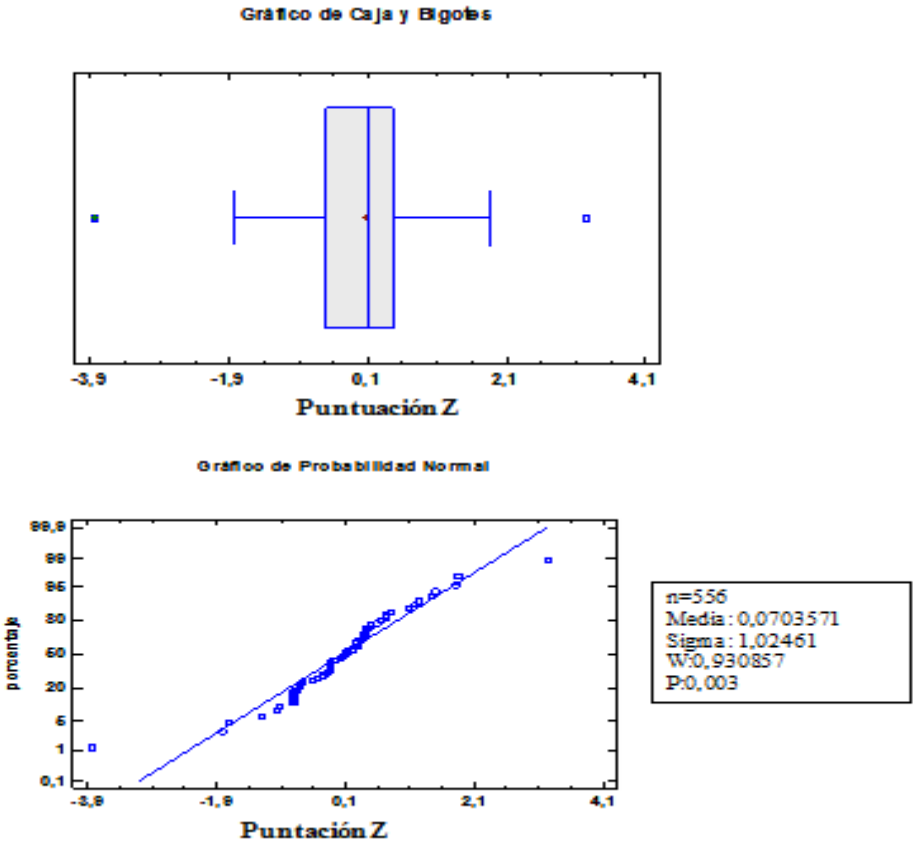
III. RESULTS AND ANALYSIS

The SD value σ = 1.02461 reveals the presence of undernutrition and overnutrition cases among students, i.e., Z < 1 o Z > 1. As established by Resolution No. 2465 of 2016 from the Colombian Ministry of Social Protection,

the Z-score is the difference between the individual and average value of the reference population for the same age or height/weight, divided by the SD of the reference population, to identify how far the individual value obtained is from the (reference population) median. Furthermore, the 7.08 range indicates that thinness and obesity cases are detected in this study as well. Standardized bias and kurtosis are of particular interest for this descriptive analysis, as they may be used to determine whether the sample is the result of a normal distribution. The values of the statistics outside the range of−2 to +2 suggest significant normality deviations, which would tend to invalidate any statistical test with regard to the SD.

In this case, the standardized bias value is within the expected range for data arising from normal distribution, with a value of −1.37906. Nonetheless, the standardized kurtosis value (6.29543) is not within the expected range (Figure 1).

Figure 1.Box-and-Whisker plot and Normal Probability plot for the Z-SCORE



Frequencies for the Z-score variable. This analysis reveals groups of students suffering from thinness ($Z - score = -3.84$), obesity ($Z - score = 3.24$), excessive weight ($1 < Z - score < 2$), and other groups at risk of thinness with ($-2 < Z - score < -1$). In total, 21.43% of the students (119/556) showed some kind of alteration in their Z-score.

BMI/AGE VARIABLE BASED ON DOE AND ANOVA

The DOE and ANOVA were used to identify the treatment(s) with the greatest impact on the Anthropometric Indicator with regard to the Z-score. This experiment corresponds to an unbalanced multiple factorial design, sampling the total number of students attending the courses under study. In this regard, the experiment's analysis focused on the study of the factors' median graph rather than their interactions. Both the factors and their levels are shown in Table 1.

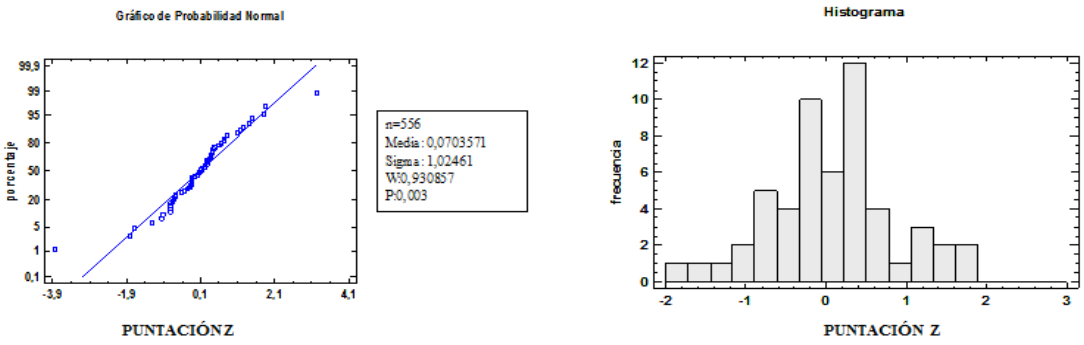
Table 1.Factor levels under study

Factor	Levels
Grade	A, B, C, 2A, 2B
Gender	Male (M), Female (F)
Age	Range 1:6.0–9.0 years Range 2:9.0–11.0 years
Weight	Range 1: 14–19.9 kg, Range 2: 20–25.9 kg, Range 3: 26–31.9 kg, Range 4: 32–37.9 kg
Height	Range 1: 1.09–1.14 cm, Range 2: 1.15–1.20 cm, Range 3: 1.21–1.26 cm, Range 4: Taller than 1.27 cm

Source: Prepared by the authors

The measurement unit is represented by each student, whereas the response variable was the Z-score obtained. The variable was randomly measured, and to confirm data normality, atypical values higher than 3σ were omitted, in this case corresponding to values of −3.84 and 3.24. The new descriptive analysis for the Z-score is shown in Figure 2. The results prove the normality of data, a compulsory requirement for the ANOVA application.

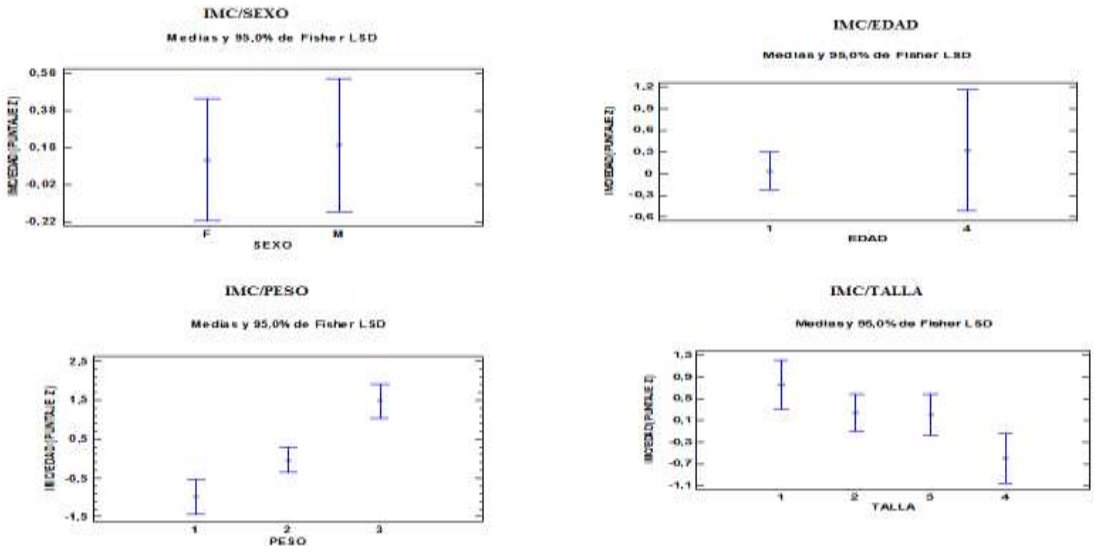
Figure 2.Normal Probability Plot and Histogram for "Trans_Z-score"



In the ANOVA, the "Z-score" variable shows statistically significant differences between the weight and height processing, with a 95% confidence level, also indicating that their *P-values* are lower than 0.05.

Exemplified in Figure 3, the LSD average graphs show the visual differences between factor processing. It can be particularly noted that several of the height and weight factor levels do not overlap, thus confirming their infrequency in the results obtained. As for *gender*, on average, the scores of male students tend to be farther from expectation, although no significant differences have been observed between the levels of these factors. With regard to *age*, young students (Range 1) have average values closer to the expected score, whereas older students (Range 2) have average values farthest from expectation, with a higher variability across measurements. For *weight*, ranges 1 and 3 are the farthest from the Z-score of 0, showing clear significant differences. With regard to *height*, it was possible to confirm the differences between levels 1 and 4 only, with average values for these levels being farthest from the expected Z-score.

Figure 3. LSD average graph for the Z-score



IV. DISCUSSION

Obesity and malnutrition are globally considered public health issues affecting more children every year and at increasingly early ages (26,27). Significant differences between the weight and height were found in this research, with a 95% confidence interval, being lower than 0.05, similar to their P-values. This confirms the considerable influence of these factors on the response variable; in other words, the nutritional status, which are considered objective indicators of the body dimension. Weight, age, and gender are reference parameters used to diagnose and quantify temporal or acute malnutrition, and the relationship between an individual's height and the age or gender-specific reference is used to diagnose chronic undernutrition. The comparison between weight and height measurements are parameters employed to evaluate body mass, while height and weight are references indicating an individual's growth. Results below normal values indicate a deficit that may be associated with the nutritional status. Both parameters are used to assess BMI (28).

In 2019, Pedro Delgado-Floody et al. conducted a study with 164 schoolchildren (93 boys and 71 girls) aged between 11 and 14 years and attending two public educational establishments in Temuco, Chile, wherein 55.4% of the sample were overweight and obese (29), unlike the research results, showing that 10.7% of them had developed obesity. These percentages are similar to those found by Pedreros et al. (2009), who carried out a study at a private school in Manaus, Brazil, involving 180 male and female students aged 9 to 17 years. The BMI showed the presence of eutrophy in 60.5% of the students, excessive weight in 20%, and obesity. The results indicate the prevalence of excessive weight and obesity, particularly among male students aged 10 and 11 years (30).

Thisstudy's findings reveal anthropometric variations among schoolchildren (21.43%) within a range of 7.08, shown by thinness, obesity, excessive weight (P<0.001), and height deficit (p=00.4). These results are in line with the cross-sectional study conducted in 2017 in São Paulo (Brazil), whose population was made up of students attending Grade 1 to 4, resulting in a sample of 3,172 children. The prevalence was 2.12% for height deficit, 0.76% for low weight, 38.32% for excessive weight, and 18.34% for obesity. This indicates a significant difference between gender regarding obesity (P< 0.001), excessive weight (P<0.001), and height deficit (p=0.03). Values were higher among girls (31) and different from those reported byAlvis-Chirinos et al.,wherein only 0.6% of them suffered from thinness (28). In Latin America and the Caribbean, the prevalence of excessive weight/obesity has steadily increased among young children. This is a current health issue worth effective interventions, especially during school age, as the dietary habits and patterns are established during this stage, to ensure a healthyadult population in the near future (32).

Obesity is closely linked to health disorders throughout childhood and is considered a morbidity and mortality risk factor for adults. The children undergoing these issues are at increased risk of developing cardiovascular, endocrine, respiratory, muscle-skeletal, digestive, and psychological diseases, among others (33).
Moreover, multiple causes of the two current problems, excessive weight and obesity, have been identified (34). The quintessential and preferred diagnosis method is anthropometry. BMI levels are associated with body fat and risk of developing health issues such as cardiovascular diseases (35, 4). If this trending behavior persists, by 2022, there will be more cases of obese children than undernourished or with lowweight, and this problem will be more common in the age group of 5–19 years (20).

The nutritional condition of young children was favorable, closer to the expected values, compared with older children. Evidence shows this may be due to their familysystem. Malnutrition in children under 5 years is mostly present when they are faced with family conflict, behavioral issues, or poor family relationships. Conversely, children with functional families have an appropriate nutritional status allowing for enhanced growth and development (36). In contrast to the abovementioned, studies indicate that the educational level of parents or guardians, rather than the family composition or structure, most influences the children's nutritional status, as reported by other research studies (28,37).

Regarding *gender*, on average, male students tend to be farther from the expected score, although no significant differences have been observed between the levels of these two factors. These findings differ from the results obtained in the study conducted by Pajuelo et al. (38), who reported different outcomes, as girls showed a higher prevalence of excessive weight/obesity (13.1%) than boys (11.2%) in their research. Maleswere shown to be the most affected by low weight (10.3%). Another identified parameter is body mass index; although its use is extensive for assessing the nutritional status of older adults, it has certain limitations and thus should beimplemented whenit is associated with other indicators (39).

The authors declare there are no conflicts of interest regarding the publication of this paper.

V. CONCLUSION

The results obtained lead to the conclusion that the scores of male schoolchildren under study were far from expectation, although no statistically significant differences were observed. Older students showed the farthest values and presented more highly variable measurements. BMI is vital to study and assess the anthropometric-nutritional evaluation to be analyzed.

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