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Comparison of Anthropometric Indicators of Overweight and Obesity, in Children and Adolescents

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Abstract

Objective: The objective is to compare anthropometric indicators of overweight and obesity in children and adolescents.

Method: descriptive, cross-sectional, prospective and correlational study, using a sample of 484 children and adolescents, aged between 6 and 15 years, from two educational institutions in Caracas. The variables are Sex, Age, Weight, Height, BMI, Waist-Height Index (WHI), Waist Weight-Circumference Index (WWCI) and Body Fat Percentage (BFP), using the Deurenberg formula. Mean, percentages, correlations were obtained and means and percentages were compared using Student's t-test.

Results: similar sex means for all indicators; discriminated by age group, they behave the same in the group of 6 to 11 years, and in the group of 12 or more years, all the averages are higher in the male sex; are significant (p<0,000). Moderate to high correlations were obtained between Age-Weight (0.69); Age-Size and Size-WWCI (0.74 – 0.76); Weight-WWCI, Weight-Height, Weight-BMI and BMI-WWCI greater than 0.84. The WHI indicator ranks 85.5% in Non-risk and 14.5% in Risk; the WWCI, classifies 84.9% in Non-risk and 15.1% in Risk.

Conclusions: The indicators classify a high percentage in Normal; the BMI/Age/WHO ranks the highest percentage in Excess, followed by the Waist Weight-Circumference Index (WWCI) and the Waist-Height Index WHI; the BMI/Age/FTE indicator classifies a lower percentage in Deficit, in two sexes; there is a high correlation between BMI and BFP, it is suggested to use BFI as a complementary indicator of BMI, to evaluate overweight and obesity in children and adolescents.

Keywords: Body Mass Index; Waist-Height Index; Weight-Waist Circumference Index; Body Fat Percentage

Introduction

Body Mass Index (BMI) is used as a screening tool to identify possible weight problems in children. CDC and American Academy of Pediatrics (AAP) recommend the use of BMI to detect overweight and obesity in children as young as 2 years of age [1].

WHO has used the Body Mass Index (BMI) to assess overweight and obesity [2]; however, some authors such as Moreno González (2010) [3], claim that BMI does not provide information about the distribution of body fat. This is an aspect of relevance, considering that abdominal fat and the distribution of fat in the body, represent different risk and is the one that is associated with greater risk of cardiovascular disease, diabetes mellitus type 2, cancer, among other diseases, on the other hand Lean et al [4] consider waist circumference as a measure to indicate risk, also recommend implementing therapeutic or preventive measures aimed at reducing this risk.

In the case of children aged 5 to 19 years, WHO defines overweight as the BMI for age with more than one standard deviation above the established median in child growth patterns; and obesity as a BMI greater than two standard deviations above the median established in childhood growth patterns [5].

On the other hand, it has been estimated that by 2016 it was estimated that some 41 million children under the age of five were overweight or obese; particularly, in Africa, the number of children under 5 years of age, who are overweight increased to about 50% between 2000 and 2016, and in Asia about half of children under 5 are overweight or obese [5].

The obese child and adolescent population increased significantly in East Asia, high-income English-speaking countries, and the Middle East and North Africa; Nauru being the country with the highest prevalence of obesity among girls and adolescents, at 33.4 per cent, and boys were the Cook Islands at 33.3 per cent; while in Europe, the highest obesity rates were recorded in Malta (for girls and adolescents) and Greece (for boys and adolescents), with 11.3 per cent and 16.7 per cent, respectively. The lowest rates of obesity in both sexes were in Moldova, at 3.2% and 5%, respectively [6].

In addition, according to UNICEF, in times of pandemic due to COVID-19, it is estimated that some 370 million children in the world have lost access to essential meals since the closure of schools; and if no action is taken, the prevalence of child wasting may increase by up to 14%, equivalent to 6 or 7 million children with this condition [7].

In Venezuela, the situation of overweight and obesity in children and adolescents, according to a study conducted by the Comprehensive Treatment Center for Obesity (CitoGroupVe), reveals that the obesity rate fell by a third between 2010 and 2017 due to the economic difficulties of recent years; such a decrease in the obesity rate from 2011 to the present, went from 24% to 11%, while that of overweight went from 30% to 25%, and that of morbid obesity went from 1.74% to 0.6%, although it does not report on the group that includes children and adolescents [8].

A study conducted by Martínez-Álvarez et al (2016) [9], demonstrates the efficacy of the Waist-Height Index, as a possible indicator to identify pre-hypertensive or hypertensive status in school-age children; As for the percentage of body fat, there are still no matching criteria to be considered an important indicator, however there are some equations that are usually used in the calculation of the PGC, and most use the different folds of the body, especially for adolescents and adults, but not for children. The Deurenberg equation seems to be the most suitable for estimating the PGC in children, since it takes into account BMI, age and sex, factors that present less variation in this age group, which is why it was selected in this study.

For the aforementioned, it is of interest this study to compare some indicators of overweight and obesity, in order to evaluate them and be able to propose the one that is most effective in diagnosing overweight and obesity in children and adolescents.

Materials and Methods

Descriptive, cross-sectional, prospective and correlational study, based on a sample of 484 children and adolescents, aged between 6 and 15 years, from two educational institutions in Caracas; of which 52.7% are male and 47.3% female. The variables Age, Weight, Height, Body Mass Index (BMI), Waist-Height Index (WHI), Body Fat Percentage (BFP) and Weight-Waist Circumference Index (WWCI) are considered. Informed consent was requested from the representatives of these children and adolescents, according to the World Medical Association, WMA (2013), related to the Declaration of Helsinki [10]; we talked with the teachers of the institutions, to agree on the day of the visit, at which time we proceeded to make the measurements and obtain the necessary data.

Anthropometric indices were obtained by applying the following formulas:

The Body Mass Index (BMI), by Quetelet's formula [11]. According to the WHO, the values of this indicator in children turn out to be useful to measure the growing global epidemic of obesity [12].

$BMI = Weight / Height^2 (Kg/m^2)$

The Waist-Size Index, by the formula suggested by Carbajal Azcona [13], is obtained by dividing the Waist Circumference (WH) by the Height:

WHI = WC / Height

The Body Fat Percentage (BFP) by the formula suggested by Deurenberg et al 1991 [12,14]:

BFP = 1.2 x BMI + 0.23 x age - 10.8 x sex - 5.4

Being Sex = 1 (for men) and 0 (for women)

The Weight-Waist Circumference Index, by the formula used by Bauce and proposed as a new indicator of overweight and obesity [15,16].

WWCI = Weight (kg) / WW (cm)

Criteria used for classification:

Children and adolescents were classified according to the BMI percentile curves for age of the CDC [17] and the Caracas Cross-Sectional Study (CCSS) [18], in order to compare a national reference with an international one.

Classification according to the CDC (2015) [17], it has that Malnutrition, BMI < p5, (equivalent to Deficit); Healthy weight, p5 ≤ BMI < p85, (equivalent to Normal); Overweight p85 ≤ BMI < p95; and Obesity BMI ≥ p95 (equivalent to Excess BMI ≥ p85).

The values taken as a national reference, according to the Transversal Study of Caracas TSC); they are: Deficit, BMI < p.3; Normal: p.3 ≤ BMI < p.97; Excess: BMI ≥ p.97 [19].

For the WHI, values < 0.50 Normal and WHI ≥ 0.51 Risk [20] were considered, and for the WWCI the values corresponding to the percentiles.

For the Body Fat Percentage (BFP), the values suggested by Moreno [21] were taken into account, for the male sex: Low (BFP < 10%), Normal (10% ≤ BDP < 20%), Overweight (20% ≤ BFP < 25%) and Obesity (BFP ≥ 25%); for females: Low (BFP < 20%), Normal (20% ≤ BFP < 30%), Overweight (30% ≤ BFP < 35%) and Obesity (BFP ≥ 25%).

To evaluate the Waist Weight-Circumference Index (WWCI), as it is a new indicator, the 85th Percentile was assumed as a reference value, which is close to the mean value and was classified according to the following categories: Deficit (WWCI < P5); Normal (P5≤ WWCI < P85); Overweight (P85 ≤ WWCI < P95) and Obesity (WWCI ≥ P95) [16]; and their equivalents Deficit (WWCI < P5), Normal (p5 ≤ WWCI < P85) and Excess (WWCI ≥ P85).

Descriptive statistical measures (mean, deviation, percentage), association (correlations, Chi square), comparison of means and percentages, using Student's t-test, and Linear regression were determined, and Logistic Regression for the Waist-Size Index.

Results

We have the descriptive measures of the variables included in the study, by sex and age group, for each of the variables and anthropometric indicators; it can be seen in Table 1, that for the total sample, the means of the four anthropometric indicators (WHI,WWC, BMI and BFP) are similar for both sexes; and when discriminated by age group, in the 6-11 age group, these averages also behave similarly; and in the 12-15 age group, the mean WHI is slightly higher in males, the WWCI average is higher in males, and slightly higher mean BMI and BFP in males. In addition, the means by sex are not significant in the total sample and in the group of 6 to 11 years, but are significant in the group of 12 to 15 years (p<0.006).

Sex	Age	Weight	Size	WHI	WWCI	BMI	BFP
Sample (n=484)							
M	10.2±2.1	34.6±17.9	136.9±13.5	0.47±0.04	0.56±0.17	18.9±3.9	8.8±4.9
F	9.9±1.9	35.9±18.9	137.2±12.7	0.47±0.04	0.56±0.15	18.6±3.2	19.3±4.0
T	10.1±2.0	35.3±18.4	137.1±13.1	0.47±0.04	0.56±0.20	18.8±3.6	13.75±6.9
p	0,1000	0,430	0,801	1,000	1,000	0,354	0,000
Boys and girls from 6 to 11 years old (n=361)							
M	9.3±1.4	32.0±16.9	131.7±10.6	0.47±0.04	0.50±0.13	17.9±3.1	13.07±6.7
F	9.2±1.5	32.6±17.2	133.1±10.8	0.47±0.04	0.53±0.14	18.1±3.7	18.4±3.8
T	9.2±1.5	32.3±17.0	132.4±10.7	0.47±0.04	0.52±0.13	18.0±3.1	14.9±6.5
p	0,450	0,699	0,152	1,000	0,015	0,479	0,000
Adolescents Aged 12 and over (n=123)							
M	12.9±0.9	45.7±20.6	151.1±10.2	0.48±0.04	0.70±0.19	21.6±4.6	12.6±5.6
F	12.5±0.7	46.7±23.5	150.2±9.3	0.47±0.04	0.65±0.14	20.4±2.7	22.1±3.4
T	12.7±0.9	46.3±22.1	150.7±9.8	0.48±0.04	0.68±0.17	21.1±3.9	16.2±3.4
p	0,000	0,621	0,310	0,006	0,001	0,000	0,000

Note: WHI: Waist-Height Index; WWCI: Waist Weight-Circumference Index; BMI: Body Mass Index; BFP: Body Fat Percentage

Table 1: Average and deviation of variables and indicators anthropometric, by sex and age group

In Table 2, it can be seen that all indicators classify a higher percentage of the female sex in Deficit; a similar percentage in the two sexes in Normal, although slightly higher in the male sex, according to the BMI/Age indicator of the CDC/WHO, and a higher percentage in the female sex in Excess, according to all the indicators.

	Deficit				Normal				Excess			
	Male		Female		Male		Female		Male		Female	
BMI/Age CDC/WHO	N	%	N	%	N	%	N	%	N	%	N	%
	8	3,1	13	5,7	181	70,9	155	67,7	66	25,9	61	26,6
BMI/Age/CCSS	N	%	N	%	N	%	N	%	N	%	N	%
	2	0,8	2	0,9	230	90,2	214	93,4	23	9,0	13	5,7
WHI	N	%	N	%	N	%	N	%	N	%	N	%
	0	0,0	0	0,0	216	84,7	198	86,5	39	15,3	31	13,5
WWCI Percentiles	N	%	N	%	N	%	N	%	N	%	N	%
	15	5,9	16	7,0	199	78,0	181	79,0	41	16,1	32	14,0
Body Fat Percentage	N	%	N	%	N	%	N	%	N	%	N	%
	0	0,0	137	59,8	156	61,2	89	38,9	99	38,8	3	1,3

Classification in Non-risk and Risk, by sex, according to the WHI and WWCI indicators								
	No Risk				risk			
	Male		Female		Male		Female	
WHI	N	%	N	%	N	%	N	%
	216	84,7	198	86,5	39	15,3	31	13,5
WWCI Percentile 85	N	%	N	%	N	%	N	%
	215	84,3	197	88,7	40	15,7	25	11,2

Note: WHI: Waist-Height Index; WWCI: Waist Weight-Circumference Index; BMI: Body Mass Index; BFP: Body Fat Percentage; CCSS: Caracas Cross-Sectional Study; CDC: Centers for Disease Control and Prevention

Table 2: Percentage comparison of the classification of the anthropometric indicators, by sex, by category

With regard to the WHI and WWCI indicators, the results of classifying boys and girls, in Risk and Non-risk, the WHI must be classified, 85.5% in Non-risk and 14.5% in Risk, of which 84.3% and 88.7% are classified as non-risk and 88.7%, male and female; and 15.3% and 13.5% of males and females at risk; while for the WWCI, considering the 85th percentile as a reference value, there is 84.9% in Non-risk and 15.1% in Risk, corresponding 84.3% to the male sex and 88.7% to the female sex, in addition to classifying 18.7% of the male sex and 11.2% of the female sex at Risk.

The BMI/Age/CCSS indicator is the one that classifies a lower percentage in Excess, to both sexes, that is, that it does not overeat when making this classification.

The significant correlations between the variables turn out to be: Age-Weight 0.69; Age-Size 0.76; WWCI-Weight 0.95; Weight-Size 0.82; BMI-weight 0.85; Size-WWCI 0.74 and BMI-WWCI 0.84. Considering that both the BMI and the WWCI and the BFP are the anthropometric indicators that are compared, we discriminated by sex and obtained regressions between these variables, which can be seen in Figure 1.

Figura 1-A. Relationship of BMI to BFP. Children and adolescents of Caracas. Male sex

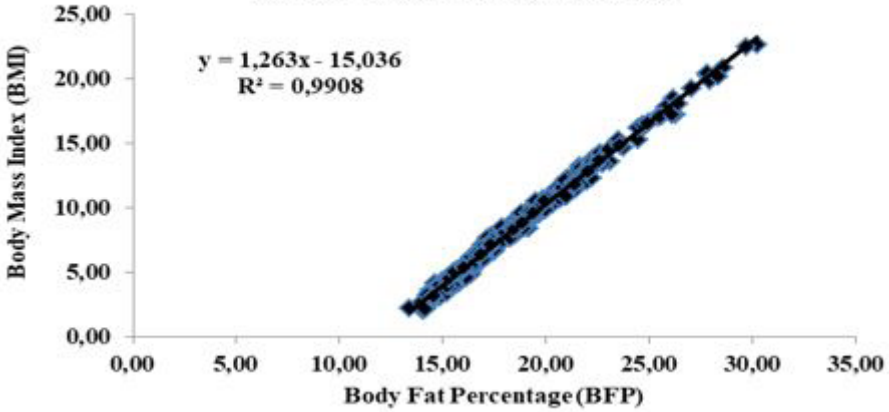


Figura 1-B. Relationship of BMI to BFP. Children and adolescents of Caracas. Female sex

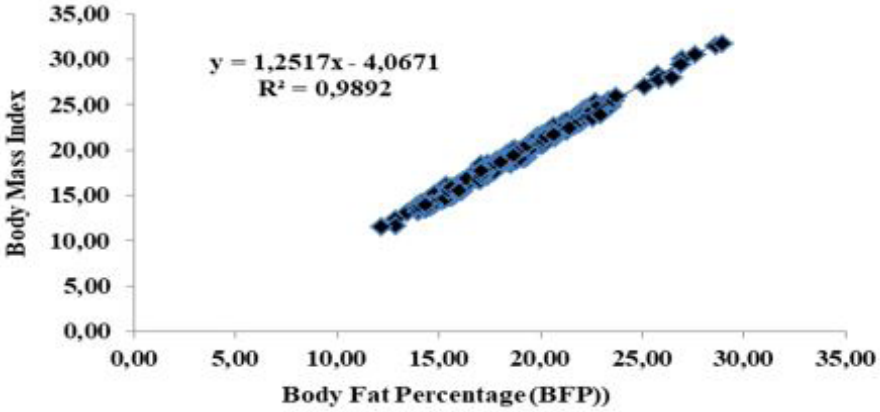
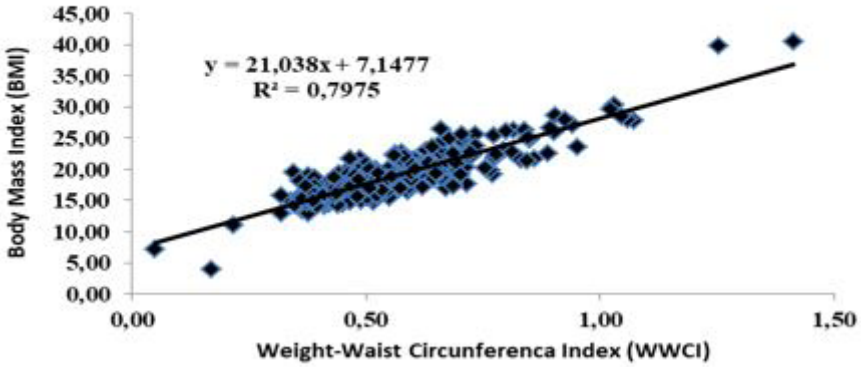


Figura 1-C. Relatiomship of BMI to WWCI. Children and adolescents of Carcas. Female sex



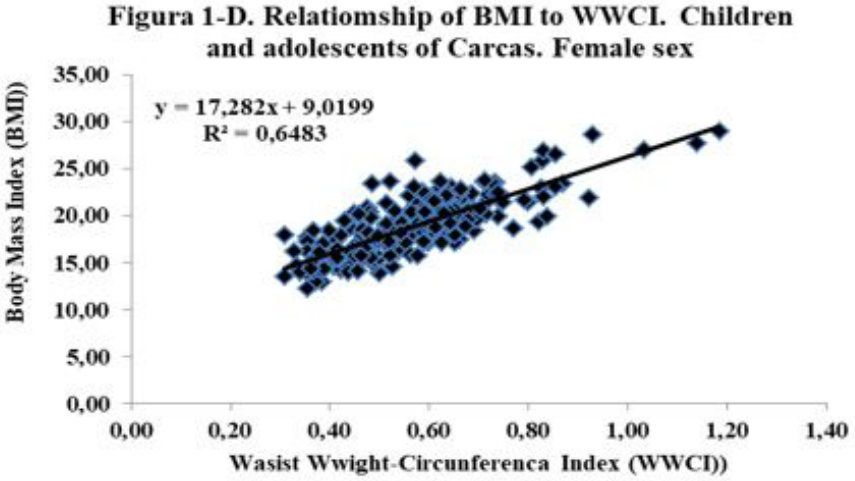


Figure 1: Relationship of BMI vs BFP and BMI vs WWCI indicators, by sex

Logistic Regression for the Waist-Size Index reveals that the model is acceptable, since the coefficients for the equation are significantly deferential to zero, as revealed by the Likelihood Ratio ($p<0.001$); likewise, the ROC curve has an area under the curve of 0.728, with a Sensitivity and Specificity greater than 0.75 (Figure 2).

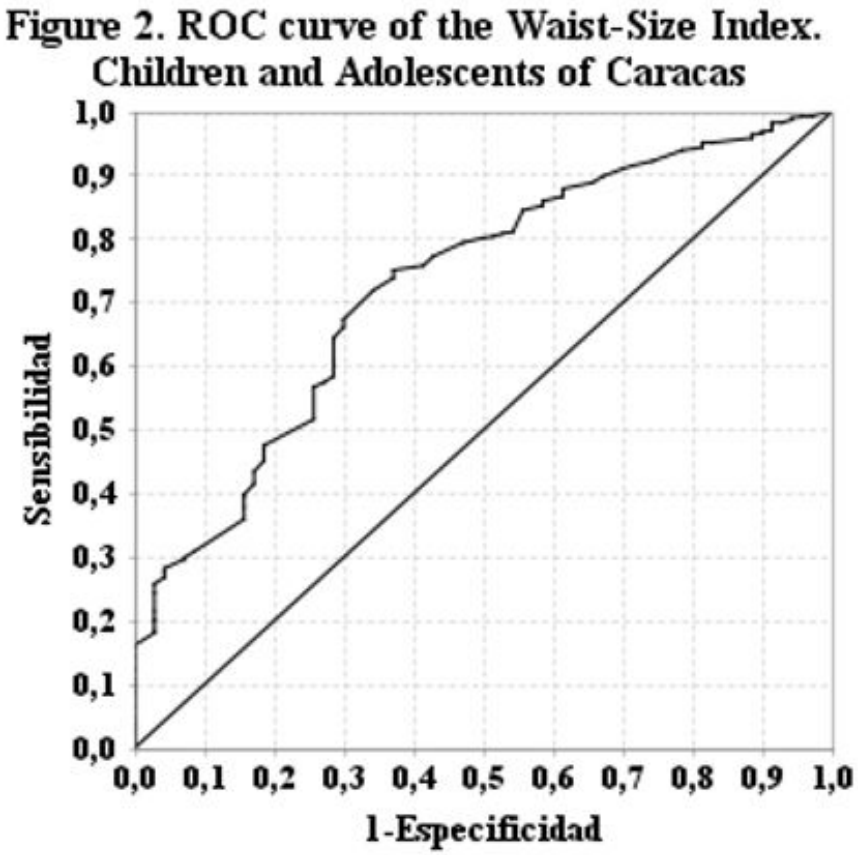


Figure 2: ROC curve of the Waist-Size Index. Children and Adolescents of Caracas

Discussion

Taking into account the results obtained, based on a sample of 484 children and adolescents, aged between 6 and 15 years, it can be stated that the means of the variables included in this study, for the total sample the averages of Weight, Height and BFP are higher in the female sex, higher in the male sex and are statistically significant (p<0,000). The averages of the WHI and WWCI indicators are the same, and the averages of the BFP higher in the female sex and statistically significant (p<0,000). When compared in two age groups 6 to 11 years and 12 or more years, it has to be that in the first the averages of Age, Weight and Height are practically the same, as in the WHI indicator; on the other hand, the average of the WWCI, BMI and BFP indicators are slightly higher in the female sex, and particularly for the BFP these are statistically significant. With regard to the second group, it is observed that the averages of Weight and Height are slightly similar, while the means of Age, WHI, WWCI, BMI and BFP are statistically significant (0.006<p< 0.000).

The anthropometric indicators are compared in three categories by sex, and show low percentages for the two sexes in Deficit with the BMI/Age/CDC/WHO indicator, and BMI/CCSS, with the exception of the WHI that does not classify any. For the Normal category, the percentages are similar, higher in males with BMI/Age/CDC/WHO and higher in females with BMI/Age/WHI, WHI and WWCI, and higher in males with BFP; for the excess category all indicators classify similar percentages, with the exception of BMI/CCSS whose percentages are lower for both sexes, and the BFP which classifies a high percentage of the male sex.

The WHI and WWCI indicators, when classifying children and adolescents in Non-Risk and Risk, classify similar percentages in the two sexes, in the category of Non-risk; and similar percentages in the male sex in the Risk category, and a slightly higher percentage in the female sex.

A study conducted by Padilla [22], in a group of students, including a subgroup younger than 13.52 years, reveals a correlation of 0,81 y 0,72 to boys and girls, between BMI and BFP, although he obtained the BFP using the triceps and subscapular folds using the Slaughter and Lohman formula, while in this study the Deurenberg formula was used, and a correlation of 0.99 was obtained for boys and girls; with coefficients of determination equal to 0.99, much higher than those obtained by the aforementioned author, who obtained coefficients of determination of 0.59 and 0.56; which explains that the variability of BMI is explained in 99 % by the variability of BFP. In addition, the regressions between the BMI with the BFP and the WWCI, reflect the linear behavior and evidence the regression coefficient, for each of the two sexes, and behave in a much more homogeneous way than those reported by this same author, which means that these two indicators can be used with confidence to evaluate overweight and obesity in children and adolescents.

With regard to the Waist-Size Index, you have to, you have to the ROC curve has an area under the curve of 0.728, with a Sensitivity and Specificity greater than 0.75, Resultado muy similar al obtenido por Martínez-Álvarez [23].

Conclusion

Based on the results and the discussion it can be concluded that the anthropometric indicators compared here, reveal that all classify a high percentage of children and adolescents in the Normal category, both sexes; the BMI/Age/WHO classifies a higher percentage in Excess, for both sexes, followed by the WWCI and the WHI; and the BMI/Age/CCSS indicator is that it classifies a lower percentage in Deficit, to both sexes; in addition, this same indicator classifies the lowest percentage of children and adolescents of both sexes in the Category Excess, which is why it is suggested to continue using it as a reference, because it is more in line with the characteristics of the population in this age group.

On the other hand, there must be a high correlation between BMI and BFP, which allows us to affirm that BFP can be used as a complementary indicator of BMI, to evaluate overweight and obesity in children and adolescents.

The BMI/Age/CCSS indicator is the one that classifies a lower percentage in Excess, to both sexes, that is, that it does not overeat when making this classification.

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