



Trabajo Original

Association of anthropometric indicators to evaluate nutritional status and cardiometabolic risk in Mexican teenagers

Asociación de indicadores antropométricos para evaluar el estado nutricional y el riesgo cardiometabólico en adolescentes mexicanos

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Abstract

Introduction: anthropometric indicators (AIs) such as waist circumference (WC), body mass index (BMI), waist/hip index (WHpI), waist/height index (WHtI) and body fat percentage (BFP) are useful tools for the diagnosis of nutritional status (NS) in adolescents. Each of these parameters has advantages and disadvantages. The purpose of the present study was to analyze the association of these AIs (WC, BMI, WHpI, WHtI, and BFP) to evaluate nutritional status and estimate the cardiometabolic risk (CMR) in Mexican adolescents.

Material and method: in a cross-sectional descriptive study, the NS was analyzed through various AIs and CMR with the WHtI criteria. Nine hundred and seventeen adolescents between 15 and 17 years old participated in the study, of whom 488 (52.9%) were female and 429 (47.1%) male, all students of middle school in Tuxtla Gutiérrez, Chiapas, Mexico.

Results and conclusion: women presented a higher prevalence of obesity according to most indicators. The WHtI was the parameter that detected the highest prevalence of obesity (31%), correlating with the BMI and the BFP. Moreover, there was evidence of a significant relation between NS (assessed by all the anthropometric indicators) and CMR. The WHtI could be considered as an adequate tool for the diagnosis of obesity associated with CMR in adolescents.

Key words:

Nutritional status.
Mexican teenagers.
Cardiometabolic risk.
Body mass index.
Waist/hip index.
Waist/height index.
Body fat percentage.

Resumen

Introducción: los indicadores antropométricos (IA) como la circunferencia de cintura (CC), el índice de masa corporal (IMC), el índice cintura/cadera (ICC), el índice cintura/talla (ICT) y el porcentaje de grasa corporal (PGC) son herramientas útiles para el diagnóstico del estado nutricional (EN) en los adolescentes. Sin embargo, cada uno de estos IA presentan ventajas y desventajas. El propósito del presente estudio fue analizar la asociación de los IA (IMC, CC, ICC, ICT y PGC) para evaluar el EN y estimar el riesgo cardiometabólico (RCM) en adolescentes mexicanos.

Material y método: el diseño del estudio fue descriptivo transversal. Se analizó el EN a través de diversos IA y el RCM bajo los criterios de ICT. Este estudio fue conducido en 917 adolescentes de entre 15 y 17 años, de los cuales 488 (52,9%) eran mujeres y 429 (47,1%) varones, todos estudiantes de nivel medio superior de Tuxtla Gutiérrez, Chiapas, México.

Resultados y conclusión: las mujeres presentaron mayor prevalencia de obesidad con la mayoría de los IA utilizados. El ICT fue el IA que detectó mayor prevalencia de obesidad (31%), correlacionándose con el IMC y el PGC. Además, se evidenció una asociación significativa entre el EN valorado por todos los IA y el RCM. El ICT podría ser considerado como una herramienta adecuada para el diagnóstico de obesidad asociada a RCM en adolescentes.

Palabras clave:

Estado nutricional.
Adolescentes
mexicanos. Riesgo
cardiometabólico.
Índice de masa
corporal. Índice
cintura/cadera.
Índice cintura/talla.
Porcentaje de grasa
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INTRODUCTION

The NS is the balance between the caloric intake and energy expenditure of an individual, an equilibrium involving physical, genetic, biological, cultural, psycho-socioeconomic, and environmental factors. These factors may cause an insufficient or excessive consumption of nutrients or an inadequate diet (1). For evaluating NS, one of the strategies is to measure the dimensions and composition of the body, thus allowing for a quantitative assessment of the growth and development of children and adolescents (2).

The BMI was proposed by Adolphe Quetelet in 1835 to define and classify obesity, being adopted by the World Health Organization (WHO) for this purpose in 1986. It is closely linked to central obesity, which in turn is associated with alterations in blood lipid levels, hyperinsulinemia and CMR (3-6). However, the relationship between the BMI and central obesity, and between the latter and CMR can be overestimated. Therefore, the WHO now recommends a set of AIs for the classification of NS to make a more accurate comparison of the prevalence of overweight and obesity in distinct populations (3,4).

Since the BMI is not useful for determining the distribution of body fat or for differentiating adipose from other tissues (or essential body fat from storage body fat), it does not lend itself to assessing adiposity (7). Thus, physicians and epidemiologists have proposed diagnosing obesity with complementary body adipose indexes, such as the WC, WHpl, and WHtl (8). These AIs can be utilized as clinical tools for identifying the risk of metabolic disorders in children and adolescents, representing a non-invasive and economical method that is easy to apply in primary medical care. Indeed, the WHtl has been described as one of the most sensitive AIs for predicting CMR in children and adolescents (9).

Bioelectrical impedance, based on the resistance of tissues to the passage of electrical current, is also an easily applied and non-invasive technique. Through the analysis of bioelectrical impedance, it is possible to distinguish between total body water, body fat, and other tissues, thus allowing the instrument to calculate the BFP (10). This technique depends on some factors linked to the electrical properties of the body, such as the hydration level, age, gender, race, and physical condition (11).

In the State of Chiapas, Mexico, there are no reports, to our knowledge, on the NS and CMR of adolescents after being assessed with multiple AIs. Hence, the present study aimed to analyze the association of five AIs (BMI, WC, WHpl, WHtl, and BFP) in order to evaluate the NS and CMR of a group of Mexican adolescents.

MATERIAL AND METHODS

PARTICIPANTS

A cross-sectional study was carried out from August to December 2017 in three public high schools of Tuxtla Gutiérrez, State of Chiapas, Mexico. Contact was made with 970 adolescents in the first semester of high school, ranging in age from 15 to 17 years. The response rate was 94.6%, with 917 agreeing to take part

Of the participants, 488 were adolescent girls (52.9%) and 429 adolescent boys (47.1%). Informed consent was signed by the corresponding parents or guardians. The lack of desire for a student to get involved in the study was an exclusion criterion. The protocol was reviewed and approved by the National Academic Committee on Bioethics of Mexico, Chiapas Chapter (Comité de la Academia Nacional Mexicana de Bioética, Capítulo Chiapas).

CHARACTERIZATION OF NUTRITIONAL STATUS

Anthropometric measurements were taken by university students, who were in the last year of the Bachelor's program of nutrition. They were previously trained in the techniques recommended by Lohman (12). The participants were examined in an upright position, with shoes removed and in a state of exhalation. Procedures were carried out from 7 to 9 a.m. in the privacy of spaces assigned by the schools. The adolescents were instructed to wear light clothing and have evacuated the bladder. Additionally, they were asked to have fasted and refrained from consuming diuretics or doing exercise during the 12 hour before examination. Individuals were weighed on an electronic scale (Tanita®, model BC-533, Arlington Heights, Illinois, USA; precision, 100 g). Height was determined with an ultrasonic stadiometer (Inkids Inlab; precision, 1 mm). The WC and hip circumference were taken with a latex tape measure (Bodyfit, precision, 1 mm). The tape was placed at the height of the navel for the WC and the greater trochanters for the hip circumference.

The characterization of NS was made with the cut-off points of the BMI established by the WHO for adolescents: < -2 standard deviation (SD), underweight; -2 to +0.99 SD, normal weight; 1 to 1.99 SD, overweight; and > 2 SD, obesity (13). In the evaluation of WC, obesity was considered at values > 75th percentile (for males, 73.6-76.5 cm; for females, 73.0-74.1 cm) (14). The WHtl standard employed for diagnosing overweight and obesity was > 0.47 and > 0.50 for males while being > 0.48 and > 0.51 for females, respectively (15). Regarding the WHpl, the cut-off point for diagnosing obesity was set at > 0.80 for females and > 0.95 for males (16). Moreover, a value ≥ 0.55 for the weight/height index was the criterion for estimating CMR (9). Finally, BFP was measured by bioimpedance, classifying the adolescents by percentiles based on gender: low body fat (P_3), healthy (P_{10} - P_{75}), high body fat (P_{90}) and obesity (P_{97}) (17,18).

STATISTICAL ANALYSIS

The calculation was made of central tendency, location, and distribution. The Kolmogorov-Smirnov test was used to verify the normal distribution of quantitative variables ($p > 0.05$). Since the majority did not fit a normal distribution, an analysis was performed with non-parametric statistics. The Mann-Whitney U test was employed to compare the average values of the distinct AIs. With the Chi-squared test, an examination was made of the association between gender and the prevalence of overweight and obesity

shown by each of the parameters, and to establish the correlation between obesity and CMR. In all cases, a significant difference was considered at $p < 0.05$. Finally, to explore the relationship between variables, the Pearson correlation coefficient (r) was computed, and dispersion graphs were constructed. The r -value > 0.8 was regarded as significant. The quantitative relation of the distinct AIs was calculated with the coefficient of determination (R^2). All statistical analyses were performed on the Statistical Package for Social Science® software, version 22 (SPSS; Chicago, IL, USA).

RESULTS

For the participating students, the average age was 15.58 ± 0.6 years, weight 60.5 ± 12.9 kg, height 161 ± 8.3 cm, WC 77.4 ± 9.7 cm, and hip circumference 95.7 ± 8.8 cm. The average values were significantly higher in males for weight, height, WC, and WHpl, and in females for BMI, WHtl, and BFP (Table I).

Among the five AIs used (Table II), the WHtl showed the highest prevalence of obesity (31%), followed by the WHpl (25.1%), BFP (21%) and WC (18.3%). Surprisingly, the BMI exhibited the lowest level of obesity (7%). The NS was gender-dependent for four of the five AIs (WC, BMI, WHpl, and BFP), according to the Chi-squared test.

Overweight was diagnosed in more females than males, based on the BMI (24% vs 20%) and the WHtl (19% vs 12%). Likewise, obesity was also more prevalent among the females, judging by the BMI, WHpl, and WHtl (Table II). For males versus females, on the

other hand, the BMI demonstrated a highest percentage of underweight (15.2% vs 8.2%) and low body fat (8.6% vs 0.6%) (Fig. 1).

A significant and positive relation was found, according to the Pearson correlation coefficient and the coefficient of determination between the BMI and WHtl ($r = 0.917$, $R^2 = 0.840$; $p < 0.05$), the BMI and WC ($r = 0.889$, $R^2 = 0.790$; $p < 0.05$), the BFP and WHtl ($r = 0.917$, $R^2 = 0.840$; $p < 0.05$), and the BFP and WC ($r = 0.889$, $R^2 = 0.790$; $p < 0.05$). A weak association existed between the BFP and BMI ($r = 0.775$, $R^2 = 0.600$; $p < 0.05$, data not graphed), while no significant relation existed between the BMI and WHpl ($r = 0.390$, $R^2 = 0.152$; $p > 0.05$) or the BFP and WHpl ($r = 0.390$; $R^2 = 0.152$; $p > 0.05$). Finally, each of the five AIs showed a significant association between NS and the estimate of CMR (Table III).

DISCUSSION

There was a significant gender difference in the average values of each of the AIs, especially the BFP, height and weight. In previous reports, a significantly higher BFP has been documented for women versus men (19,11), probably due in large part to the distinct distribution of body fat in the two genders (20). Furthermore, three of the five AIs considered presently revealed a higher percentage of obesity in females versus males (the BMI, WHpl, and WHtl). The WHpl depicted the higher difference in obesity between females and males. This evaluation is based on the level of intra-abdominal fat, which coincides with gynecoid-type obesity (20).

Among the five AIs used herein, BMI reflected the lowest level of obesity, in agreement with previous studies that found this parameter able to estimate body composition but unable to correctly assesses obesity (21,22). This disadvantage of the BMI could owe itself to multiple factors, such as the influence of race and gender on its value in young people (23,24), as well as its inability to distinguish storage adipose tissue from essential adipose tissue and other lean body mass (25).

Compared to the WHpl and WHtl, the BMI is at a relative disadvantage in its ability to distinguish central from gynecoid obesity (15,26).

The prevalence of obesity calculated by the WC (18.3%), WHpl (25.1%) and BFP (21%) was like that existing in the total sample. It may be due in part to the ability of these variables to indirectly measure central adiposity (27) and estimate CMR (28-30). Additionally, the WHtl demonstrated a higher capacity to detect obesity (31%) than the other AIs, perhaps because of its direct connection with the WC, which in turn indirectly determines the quantity of abdominal fat (21,26).

On the other hand, the substantial percentage of adolescents at low weight (11%) in both genders is alarming, since underweight is known to be linked to cognitive alterations (31) and susceptibility to infections (32).

A strong association was established between the BMI and WHtl, as well as between the BFP and WC. These results are congruent with the reports by Beck on the efficacy of the WC and WHtl for predicting high blood pressure in children and adolescents (33,34).

Table I. Comparison of the anthropometric variables of the study participants by gender

Variable	Males X ± (σ)	Females X ± (σ)	Z-score	*p
Weight (kg)	63.9 ± (13.8)	57.5 ± (11.2)	7.51	< 0.05
Height (cm)	167.1 ± (6.5)	156 ± (6.0)	20.69	
WC	78.8 ± (10.7)	76.1 ± (8.7)	3.24	
BMI	22.9 ± (4.5)	23.6 ± (4.2)	3.13	
WHpl	0.828 ± (0.05)	0.789 ± (0.04)	11.21	
WHtl	0.472 ± (0.06)	0.488 ± (0.05)	5.21	
BFP	17.79 ± (7.85)	28.31 ± (6.73)	18.05	

Data are expressed as the mean (X) ± standard deviation (σ) of weight in kg, height in cm, waist circumference (WC) in cm, body mass index (BMI), waist/hip index (WHpl), waist/height index (WHtl) and the body fat percentage (BFP), using the Mann-Whitney U test (males vs females; z-score, *p < 0.05).

Table II. Comparison of the nutritional status of study participants by gender, according to five anthropometric indicators

AI	NS	♂		♀		♂		χ^2	p*
		n	%	n	%	n	%		
WC	Without obesity	750	81.7	427	46.5	323	35.2	388.0	0.005
	With obesity	167	18.3	61	6.6	106	11.5		
BMI	Underweight	105	11.5	40	8.2	65	15.2	11.8	0.008
	Normal	539	58.8	291	59.6	248	57.8		
	Overweight	203	22.1	117	24.0	86	20.0		
	Obesity	70	7.6	40	8.2	30	7.0		
WHpl	Without obesity	687	74.9	261	53.4	426	99.3	255	0.000
	With obesity	230	25.1	227	46.6	3	0.7		
WHTl	Overweight	150	16.3	95	19.4	55	12.8	2.71	0.09
	Obesity	283	31.0	156	32.0	127	29.6		
BFP	Low in body fat	40	4	3	0.6	37	8.6	36.5	0.000
	Healthy	509	56	291	60.0	218	51.0		
	High in body fat	174	19	93	19.0	81	19.0		
	Obesity	194	21	101	20.4	93	21.4		

Data show the partial number (n) or total number (N) of adolescents grouped in a classification of nutritional status (NS) by gender (females ♀ or males ♂). The NS is diagnosed by five anthropometric indicators (AIs). WC: waist circumference; BMI: body mass index; WHpl: waist/hip index; WHTl: waist/height index; BFP: body fat percentage. Chi-squared test (χ^2 ; *p < 0.05).

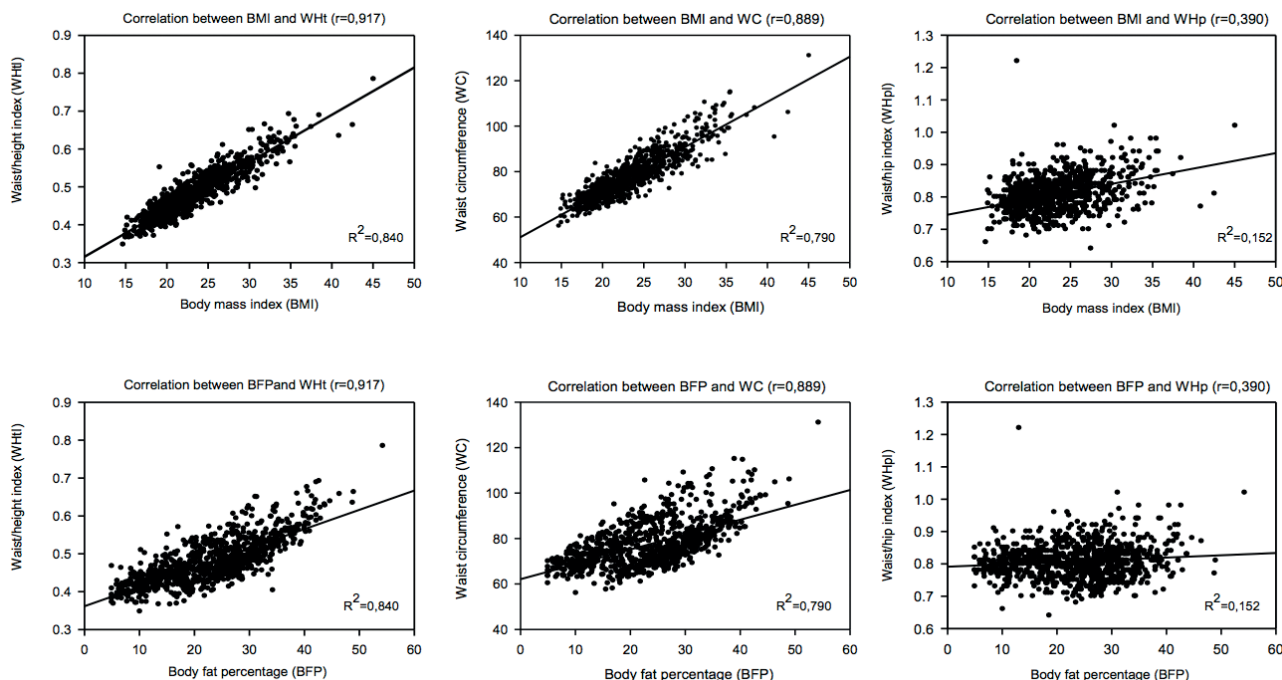


Figure 1.

Analysis of the correlation of diverse anthropometric indicators by the Pearson correlation coefficient (r) and the coefficient of determination (R²)

Table III. Relationship of nutritional status with cardiometabolic risk

AI	NS	Without cardio-metabolic risk	With cardio-metabolic risk	χ^2	P*
WC	Without obesity	730	20	223.11	0.000
	With obesity	67	100		
BMI	Overweight	150	53	90.68	0.000
	Obesity	6	64		
WHpl	Without obesity	632	55	383.82	0.000
	With obesity	165	65		
WHtl	Overweight	149	1	84.81	0.000
	Obesity	163	120		
BFP	High in body fat	165	9	104.47	0.000
	Obesity	88	106		

The diagnosis of nutritional status (NS) is given for each anthropometric indicator (AI), along with the association of this parameter to cardiometabolic risk. WC: waist circumference; BMI: body mass index; WHpl: waist/hip index; WHtl: waist/height index; BFP: body fat percentage. Chi-squared test (χ^2 ; *p < 0.05).

Moreover, each of the five AIs included in the current contribution showed a significant correlation between NS and CMR.

The disadvantage of the present parameters is their incapacity to distinguish gynecoid from central obesity or detect a higher distribution of body fat at the thoracic level. Furthermore, it is indispensable to consider height as a possible factor of bias when comparing data on obesity between populations of European origin and those in Latin America. This factor may skew data when diagnosing obesity with the WHtl, the BMI, or both (35).

In the present cross-sectional study, consideration should be given to some factors that may have influenced the results and their interpretation, such as the lack of an inferential sample. Moreover, there are no published tables with the percentiles of the key AIs related to overweight and obesity for the population of the state of Chiapas, a deficiency that should be considered in the design of future research. A set of anthropometric criteria for establishing the prevalence of NS and CMR needs to be developed and standardized.

In conclusion, the WHtl represents an adequate tool for the diagnosis of obesity associated with CMR in adolescents, compared to the other AIs presently studied. It is important to continue investigating the efficacy of estimating CMR with AIs, some of which could be effectively combined with the gold standards, especially the lipid profile and fasting glucose.

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