Nutrición Hospitalaria

SENPE

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

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

10.20960/nh.02487

OR 2487

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

Mauricio Megchún-Hernández[1], Judith Espinosa-Raya[1], Esmeralda García-Parra[2], Cidronio Albavera-Hernández[3] and Alfredo Briones-Aranda[4]

[1]Escuela Superior de Medicina. Instituto Politécnico Nacional. Ciudad de México, México. [2]Facultad de Ciencias de la Nutrición y Alimentos. Universidad de Ciencias y Artes. Chiapas, México. [3]Instituto Mexicano del Seguro Social. Universidad Latinoamericana. Morelos, México. [4]Facultad de Medicina Humana. Universidad Autónoma de Chiapas. Chiapas, México

Received: 16/05/2019

Accepted: 02/07/2019

Correspondence: Alfredo Briones Aranda. Facultad de Medicina Humana. Universidad Autónoma de Chiapas. Decima sur esquina calle central, colonia centro. Tuxtla Gutiérrez Chiapas. México

e-mail: alfred725@hotmail.com

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 corporal.

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, physician doctors and epidemiologists have proposed diagnosing obesity with complementary body adipose indexes, such as the WC, WHpI, and

WHtI (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 WHtI 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, WHpI, WHtI, 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 WHtI 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 WHpI, 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 WHpI, and in females for BMI, WHtI, and BFP (Table I).

Among the five AIs used (Table II), the WHtI showed the highest prevalence of obesity (31%), followed by the WHpI (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, WHpI, 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 WHtI (19% *vs* 12%). Likewise, obesity was also more prevalent among the females, judging by the BMI, WHpI, and WHtI (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 WHtI ($r = 0.917$, $R^2 = 0.840$; $p < 0.05$), the BMI and WC ($r = 0.889$, $R^2 = 0.790$; $p < 0.05$), the BFP and WHtI ($r = 0.917$, $R^2 = 0.840$; $p < 0.05$), 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 WHpI ($r = 0.390$, $R^2 = 0.152$; $p > 0.05$) or the BFP and WHpI ($r = 0.390$; $R^2 = 0.152$; $p > 0.05$). 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, WHpI, and WHtI). The WHpI 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 WHpI and WHtI, 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%), WHpI (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 WHtI 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 WHtI, as well as between the BFP and WC. These results are congruent with the reports by Beck on the efficacy of the WC and WHtI for predicting high blood pressure in children and adolescents (33,34). 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 WHtI, the BMI, o 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 WHtI 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.

REFERENCES

1. Figueroa-Pedraza D. Nutritional status as a factor and a result of nutritional and food security and their representations in Brazil. Rev Salud Publica (Bogota) 2004;6(2):140-55.

2. Ravasco P, Anderson H, Mardones F. Métodos de valoración del estado nutricional. Nutr Hosp 2010;25(Suppl 3):57-66.

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. Lancet 2017;390(10113):2627-42.

2. Puche RC. Body mass index and the reasoning of an astronomer. Medicina (B Aires) 2005;65(4):361-5.

3. Lek N, Yan W, Zhang Y, Wang Q, Cheung YB. Indices of central and general obesity and cardiometabolic risk among adolescents in three ethnic groups in north-west China. Ann Hum Biol 2016;43(1):18-24.

4. Ali O, Cerjak D, Kent JW, James R, Blangero J, Zhang Y. Obesity, central adiposity and cardiometabolic risk factors in children and adolescents: a family-based study. Pediatr Obes 2014;9(3):e58-e62.

5. Ochoa-Díaz-López H, García-Parra E, Flores-Guillén E, García-Miranda R, Solís-Hernández R. Evaluación del estado nutricional en menores de 5 años: concordancia entre índices antropométricos en población indígena de Chiapas (México). Nutr Hosp 2017;34(4):820-6.

6. Olatunbosun ST, Kaufman JS, Bella AF. Central obesity in Africans: anthropometric assessment of abdominal adiposity and its predictors in urban Nigerians. J Natl Med Assoc 2018;110(5):519-27.

7. Arnaiz P, Acevedo M, Díaz C, Bancalari R, Barja S, Aglony M, et al. Razón cintura estatura como predictor de riesgo cardiometabólico en niños y adolescentes. Rev Chil Cardiol 2010;29(3):281-8.

8. Verney J, Metz L, Chaplais E, Cardenoux C, Pereira B, Thivel D. Bioelectrical impedance is an accurate method to assess body composition in obese but not severely obese adolescents. Nutr Res 2016;36(7):663-70.

9. González-Ruiz K, Medrano M, Correa-Bautista JE, García-Hermoso A, Prieto-Benavides DH, Tordecilla-Sanders A, et al. Comparison of bioelectrical impedance analysis, slaughter skinfold-thickness equations, and dual-energy x-ray absorptiometry for estimating body fat percentage in Colombian children and adolescents with excess of adiposity. Nutrients 2018;10(8)E1086.

1. Lohman TG, Roche AF, Martorell R (eds.). Anthropometric standardization reference manual. Champaign, IL: Human Kinetics; 1988.

10. De Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007;85(9):660-7.

11. Lagos-Grisales G, Cediel-Collazos V, Rodríguez-Morales AJ. Reference values of waist circumference and waist/hip ratio in children and adolescents of Mérida, Venezuela. Endocrinol Nutr 2014;61(2):113-4.

12. Marrodán MD, Martínez-Álvarez JR, González-Montero de Espinosa M, López-Ejeda N, Cabañas MD, Prado C. Diagnostic accuracy of waist to height ratio in screening of overweight and infant obesity. Med Clin (Barc) 2013;140(7):296-301.

13. Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Varying sensitivity of waist action levels to identify subjects with overweight or obesity in 19 populations of the WHO MONICA Project. J Clin Epidemiol 1999;52(12):1213-24.

14. Escobar-Cardozo GD, Correa-Bautista JE, González-Jiménez E, Schmidt-RioValle J, Ramírez-Vélez R. Percentiles of body fat measured by bioelectrical impedance in children and adolescents from Bogotá (Colombia): the FUPRECOL study. Arch Argent Pediatr 2016;114(2):135-42.

15. McCarthy HD, Cole TJ, Fry T, Jebb SA, Prentice AM. Body fat reference curves for children. Int J Obes (Lond) 2006;30(4):598-602.

16. Tao RW, Wan YH, Zhang H, Wang YF, Wang B, Xu L, et al. Relationship between hypertension and percentage of body fat, in children of Anhui province. Zhonghua Liuxingbingxue Zazhi 2016;37(2):178-82.

17. Riobó P, Fernández Bobadilla B, Kozarcewski M, Fernández Moya JM. Obesidad en la mujer. Nutr Hosp 2003;18(5):233-7.

18. Rosales RY. Anthropometry in the diagnosis of obese patients: a review. Nutr Hosp 2012;27(6):1803-9.
19. Dong J, Ni YQ, Chu X, Liu YQ, Liu GX, Zhao J, et al. Association between the abdominal obesity anthropometric indicators and metabolic disorders in a Chinese population. Public Health 2016;131:3-10.
20. Persky S, De Heer HD, McBride CM, Reid RJ. The role of weight, race, and health care experiences in care use among young men and women. Obesity (Silver Spring) 2014;22(4):1194-200.
21. Wee CC, Huskey KW, Bolcic-Jankovic D, Colten ME, Davis RB, Hamel M. Sex, race, and consideration of bariatric surgery among primary care patients with moderate to severe obesity. J Gen Intern Med 2014;29(1):68-75.
22. Fosbøl MØ, Zerahn B. Contemporary methods of body composition measurement. Clin Physiol Funct Imaging 2015;35(2):81-97. DOI: 10.1111/cpf.12152
23. Magalhães EI, Sant'Ana LF, Priore SE, Franceschini Sdo C. Waist circumference, waist/height ratio, and neck circumference as parameters of central obesity assessment in children. Rev Paul Pediatr 2014;32(3):273-81.
24. Kalker U, Hövels O, Kolbe-Saborowski H. Obese children and adolescents. Waist-hip ratio and cardiovascular risk. Monatsschr Kinderheilkd 1993;141(1):36-41.
25. Gröber-Grätz D, Widhalm K, De Zwaan M, Reinehr T, Blüher S, Schwab KO, et al. Body mass index or waist circumference: which is the better predictor for hypertension and dyslipidemia in overweight/obese children and adolescents? Association of cardiovascular risk related to body mass index or waist circumference. Horm Res Paediatr 2013;80(3):170-8.
26. Zhao M, Bovet P, Ma C, Xi B. Performance of different adiposity measures for predicting cardiovascular risk in adolescents. Sci Rep 2017;7:43686.
27. Perona JS, Schmidt-RioValle J, Rueda-Medina B, Correa-Rodríguez M, González-Jiménez E. Waist circumference shows the highest predictive

value for metabolic syndrome, and waist-to-hip ratio for its components, in Spanish adolescents. Nutr Res 2017;45:38-45.
28. Biezonski D, Cha J, Steinglass J, Posner J. Evidence for thalamocortical circuit abnormalities and associated cognitive dysfunctions in underweight individuals with anorexia nervosa. Neuropsychopharmacol 2016;41(6):1560-8.
29. Alicke M, Boakye-Appiah JK, Abdul-Jalil I, Henze A, Van der Giet M, Schulze MB, et al. Adolescent health in rural Ghana: a cross-sectional study on the co-occurrence of infectious diseases, malnutrition and cardio-metabolic risk factors. PLoS One 2017;12(7):e0180436.
30. Beck CC, Lopes-Adair DS, Pitanga-Francisco JG. Indicadores antropométricos como predictores de presión arterial elevada en adolescentes. Arq Bras Cardiol 2011;96(2):126-33.
31. Martínez-Álvarez JR, Villarino-Marín A, García-Alcón RM, López-Ejeda N, Marrodán-Serrano MD. El índice cintura-talla es un eficaz indicador antropométrico de la hipertensión en escolares. Nutr Hosp 2016;33(2):506-7.
32. Martín Castellanos Á, Cabañas Armesilla MD, Barca Durán FJ, Martín Castellanos P, Gómez Barrado JJ. Obesity and risk of myocardial infarction in a sample of European males. Waist to-hip-ratio presents information bias of the real risk of abdominal obesity. Nutr Hosp 2017;34(1):88-95.

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	
Height (cm)	167.1 ± (6.5)	156 ± (6.0)	20.69	
WC	78.8 ± (10.7)	76.1 ± (8.7)	3.24	*< 0.05*
BMI	22.9 ± (4.5)	23.6 ± (4.2)	3.13	
WHpI	0.828 ± (0.05)	0.789 ± (0.04)	11.21	
WHtI	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 (WHpI), waist/height index (WHtI) 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*	♀♂ N	%	♀ N	%	♂ n	%	X^2	**p*
WC	Without obesity	750	81.7	427	46.5	323	35.2		*0.005*
	With obesity	167	18.3	61	6.6	106	11.5	388.0	
BMI	Underweight	105	11.5	40	8.2	65	15.2		
	Normal	539	58.8	291	59.6	248	57.8		
	Overweight	203	22.1	117	24.0	86	20.0	11.8	*0.008*
	Obesity	70	7.6	40	8.2	30	7.0		
WHpI	Without obesity	687	74.9	261	53.4	426	99.3		
	With obesity	230	25.1	227	46.6	3	0.7	255	*0.000*
WHtI	Overweight	150	16.3	95	19.4	55	12.8		
	Obesity	283	31.0	156	32.0	127	29.6	2.71	*0.09*
BFP	Low in body fat	40	4	3	0.6	37	8.6		
	Healthy	509	56	291	60.0	218	51.0		
	High in body fat	174	19	93	19.0	81	19.0	36.5	*0.000*
	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; WHpI: waist/hip index; WHtI: waist/height index; BFP: body fat percentage. Chi-squared test (X^2; *$p < 0.05$).

Table III. Relationship of nutritional status with cardiometabolic risk

AI	*NS*	Without cardiometabolic risk	With cardiometabolic risk	X^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		
WHpI	Without obesity	632	55	383.82	*0.000*
	With obesity	165	65		
WHtI	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; WHpI: waist/hip index; WHtI: waist/height index; BFP: body fat percentage. Chi-squared test (X^2; *$p < 0.05$).

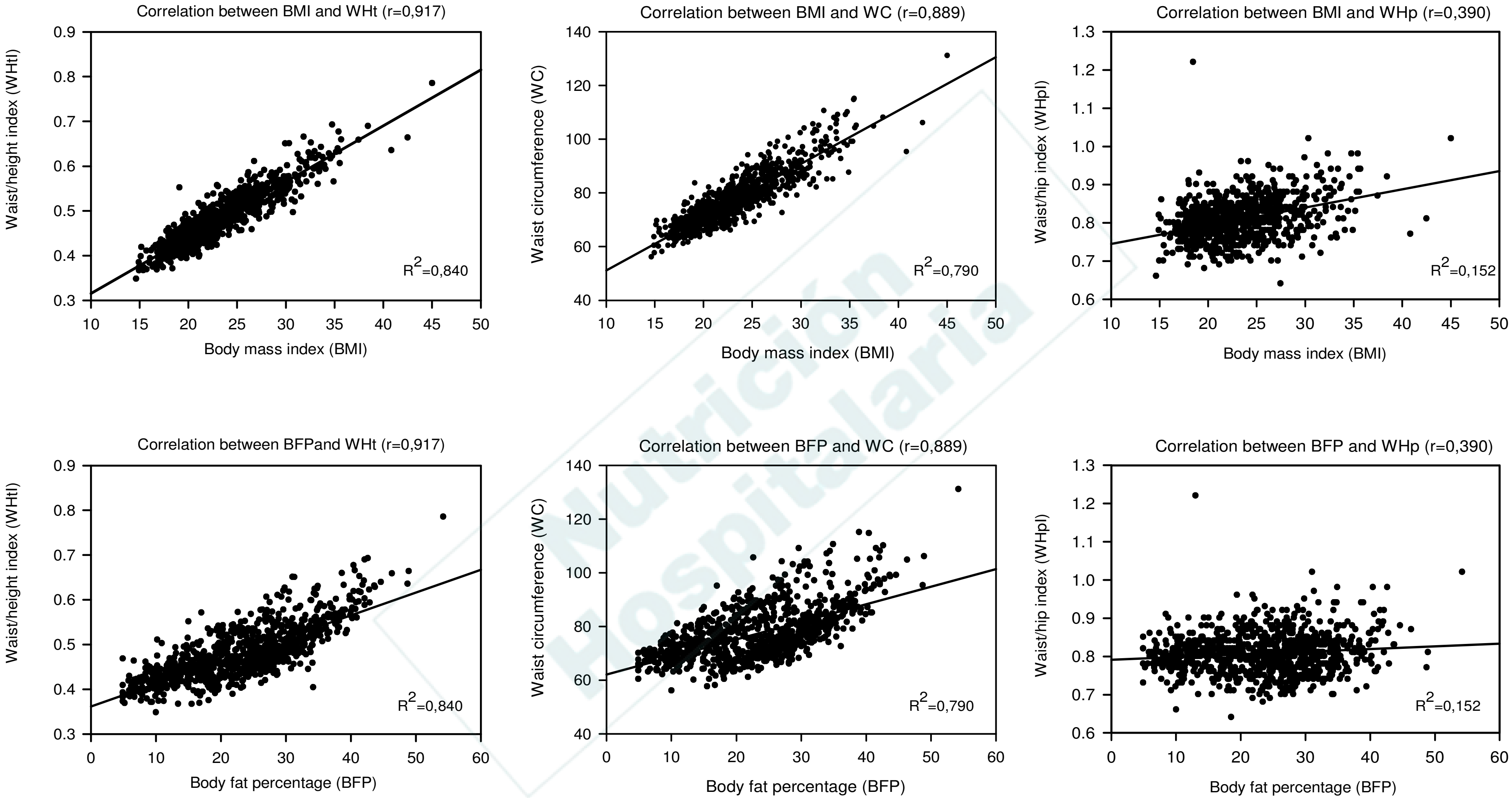
Correlation between BMI and WHt (r=0,917)
Waist/height index (WHtI)
Body mass index (BMI)
R2=0,840
Correlation between BMI and WC (r=0,889)
Waist circumference (WC)
Body mass index (BMI)
R2=0,790
Correlation between BMI and WHp (r=0,390)
Waist/hip index (WHpI)
Body mass index (BMI)
R2=0,152
Correlation between BFPand WHt (r=0,917)
Waist/height index (WHtI)
Body fat percentage (BFP)
R2=0,840
Correlation between BFP and WC (r=0,889)
Waist circumference (WC)
Body fat percentage (BFP)
R2=0,790
Correlation between BFP and WHp (r=0,390)
Waist/hip index (WHpI)
Body fat percentage (BFP)
R2=0,152

Fig. 1. Analysis of the correlation of diverse anthropometric indicators by the Pearson correlation coefficient (r) and the coefficient of determination (R^2).