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Body composition by bioelectrical

impedance analysis and prevalence of obesity in school-age children

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Summary

Background: the interest in the direct assessment of adiposity is increasing. The aim was to assess fat mass and lean mass by bioelectrical impedance, and to analyze the correlation between percentage Body Fat-body mass index and percentage Body Fat-WC, and determine the prevalence of overweight and obesity in a sample of school-age children.

Methods: a cross-sectional study were performed in 360 children; differences between the sexes were assessed by independent t-test. Prevalence of overweight and obesity were calculated according to body mass index and two percentage body fat-based cutoffs.

Results; there was no significant gender difference in body mass index ($p = 0.91$), while the boys were both taller and present more abdominal obesity but with lower mean % body fat ($p < 0.00$). The body mass index criteria show a high prevalence for overweight and obesity in boys (12.7 % and 17.7 %) than girls (12 % and 13.9 %).

Conclusions: is an urgent need to implement preventive actions among school children to decrease the of the prevalence of childhood obesity that constitutes an important health problem in Mexico.

Key words

body composition
electric impedance
child
obesity
overweight
body mass index

Resumen

Objetivo: evaluar en niños el porcentaje de grasa corporal, masa grasa, masa magra mediante impedancia bioeléctrica, para analizar la correlación entre la grasa corporal y el índice de masa corporal (IMC) y el perímetro de cintura, y determinar la prevalencia de sobrepeso y obesidad por estadio puberal.

Métodos: estudio transversal de 360 niños, las diferencias entre sexos fueron evaluadas con t de Student para muestras independientes. La prevalencia de sobrepeso y obesidad fue calculada de acuerdo con el IMC y en dos puntos de corte de porcentaje de grasa corporal.

Resultados: no hubo diferencias significativas en sexo con el IMC ($p = 0.91$); los niños fueron mas altos y presentaron más obesidad abdominal pero menos porcentaje de grasa corporal ($p < 0.00$). Se observó mayor prevalencia de sobrepeso y obesidad en niños (12.7 y 17.7 %) que en niñas (12 y 13.9 %). Con el punto de McCarthy hubo menos prevalencia combinada en el total de la muestra (53.4 %); con el de Mueller, menos prevalencia de sobrepeso (niñas 6.2 %, niños 10 %), con incremento para obesidad (niñas 16.6 %, niños 23.5 %).

Conclusiones: urgen acciones preventivas en las escuelas para disminuir el alarmante incremento de la obesidad infantil.

Palabras clave

composición corporal
impedancia eléctrica
obesidad
sobrepeso
niño
índice de masa corporal

Introduction

The study of body composition is essential to understand the impact of diet, growth, physical activity, disease and other environmental factors on the body. The assessment of the nutritional status of the monitoring of patients with acute or chronic malnutrition, and the diagnosis and classification of risk associated with obesity also contributes in different ways and at different levels in the diagnosis treatment and assessment of nutritional status in many medical specialties.[1,2] During the last two decades, overweight and obesity have become the most widespread nutritional disorders in children and adolescents in many countries in worldwide.[3,4] Currently, school-age children of almost all regions of the world

experience some degree of overweight or obesity.[5] Childhood overweight affects self-esteem and has negative consequences on cognitive and social development.[6] Loa physical activity and poor nutrition are widely acknowledged as the primary mechanisms underlying the rise in excess body weight.[7] Conditions such as type 2 diabetes mellitus, insulin resistance, dyslipidemia, metabolic syndrome and log-term vascular complications which were previously seen primarily in adults, are becoming more common among children as the prevalence of obesity increase.[8,9] In Mexico, the overweight and obesity are a health problem. According to the 2006 National Health and Nutrition Surveys (ENSANUT 2006) in Mexican children aged between 5 and 11 years, the prevalence combined of overweight and obesity was 26 % for both sexes (26.8 % girls and 25.9 % boys) which represented about 4 158 800 school-aged children. The obesity epidemic constitutes a substantial decrease in quality of life and life expectancy, hence the importance of prevention, detection and treatment them on time.[10,11] In the south area of the state of Tamaulipas in Mexico has only been used the BMI in large-scale population surveys and clinical/public health screening, but has not been measured the body composition in school population by, (BIA). The aim was to assess in girls and boys, separately, the percent body fat bioelectrical impedance analysis, fat mass, lean mass by BIA also analyzed the correlations between % BF-(BMI) and % BF-waist circum perence (WC) and determined using a Centers for disease control (CDC) criteria and two different % BF-based cutoffs, the prevalence for overweight and obesity by pubertal status in a representative sample of school-age children in Tampico, Tamaulipas, Mexico.

Methods

Study subjects

Boys and girls, aged 7-15 from three elementary school and three high school belonging to the school year 2007-2008, were included in the study. The sample size was calculated considering the prevalence of obesity in Mexico children that is approximately 26 %; the confidence level was established at 95 % and 5 % of level of precision. The established number of subjects was 295. The schools were randomly chosen, and the participants were selected from the groups of each grade by sampling probabilistic random sample and systematic random selection for children to study in case of the teenage population. Informed consents were obtained from their parents or guardians and all children and adolescents assented to participate in the study. Exclusion criteria were diabetes, pathological states likely to affect growth or body composition or use orthopedic device. The Ethics and Research Committee of the General Regional Hospital No. 6, Mexican Institute of Social Security approved the study.

Measurements

(% BF) All measurements were conducted in the schools between 08:00 and 10:00 hours. Participants removed their shoes and wearing light clothing. Body weight was measured recorded to the nearest 0.1 kg using a digital scale (Tanita Corporation, Japan). Height was obtained by using a portable stadiometer

Table I | **Characteristics of the studied population***

	Girls (*n* = 156)	Boys (*n* = 160)	All (*n* = 316)	*p* **
Age (years)	11.40 ± 2.56	11.58 ± 2.43	11.49 ± 2.49	0.54
Height (m)	1.48 ± 0.13	1.52 ± 0.15	1.5 ± 0.14	0.01
Weight (kg)	49.72 ± 16.82	52.75 ± 16.55	51.25 ± 16.72	0.10
WC (cm)***	77.38 ± 13.54	80.43 ± 13.41	78.92 ± 13.54	0.04
BMI (kg/m^2)***	22.18 ± 5.33	22.24 ± 4.69	22.21 ± 5.01	0.91
% BF***	29.12 ± 9.39	23.11 ± 10.71	26.07 ± 10.50	0.00
Fat Mass (kg)	15.67 ± 9.48	12.81 ± 8.72	14.22 ± 9.20	0.05
Lean Mass (kg)	34.05 ± 8.27	39.96 ± 11.42	37.04 ± 10.41	0.00

**Reported values are mean ± SD*

***A p-value refer to independent t-tests less than 0.05 were regarded as significant*

****Pearson correlations between % BF-BMI, % BF-WC p < 0.00 for all correlations*

WC = waist circumference, BMI = body mass index, %BF = percent body fat

225cm (SECA, Hamburg, Germany) to nearest 0.1 cm. BMI was calculated as weight (kg) divided by height squared (m^2). Body composition was assessed by BIA using a TANITA TBF310 model with a frequency of 50 kHz. Height, sex and age were entered manually, while weight was recorded automatically using 0.5 kg as an adjustment for clothing weight in all subjects. Measurements were taken at a similar time point each day after an overnight fast and limited physical exertion in an attempt to reduce measurement error. Waist circumference was measured in standing position between the highest point of the iliac crest and the lowest part of the costal margin at the mid-axillary line at the end of an exhalation. Blood pressure (BP) was measured using a column sphygmomanometer of mercury in right arm in a sitting position following a 10-min rest period, with appropriate cuff size for arm length, systolic blood pressure (SBP) was determined by the first Korotkoff sound and diastolic blood pressured (DBP) by the last heard Korotkoff sound.

Definitions of variables

Overweight was defined as a BMI > 85th to < 95th percentile and obesity if BMI > 95th percentile for children of the same age and sex, according to the tables of the Center for Disease Control (CDC).[12] Because there is not still a body fat reference percentile curves for Mexican children, we used two different % BF-based cutoffs, namely the ones proposed by McCarthy et al[13] and Mueller et al.[14] The cutoffs proposed by McCarthy et al based on the 85th and 95th, were derived from a sample of 1985 Caucasian children from southern England, and they had their % BF estimated by BIA (Tanita BC-418MA). They used the term "overfatness" to denote adiposity exceeding the 85th percentile, and obesity for % BF exceeding the 95th. In the study of Mueller et al proposed that the 85th percentile of % BF may be tentatively considered a clinically useful cutoff point for the definition of excessive (unhealthy) body fat. Abdominal obesity was catalogued with a WC > 90th percentile.[15] Blood pressure was considered high if it was >90th percentile, according to the age, sex and height without considering prehypertension or hypertension categories.[16] Pubertal status was self-assessed using Tanner's criteria. A self-evaluation method, with figures, was used to identify the degree of development of genital organs, breast and pubic hair.[17]

Statistical analysis

The analysis was performed by using SPSS for Windows (version 12; SPSS Inc, Chicago IL, USA). Descriptive statics were calculated by sex and age; values are expressed as means

Table II | **Prevalence of overweight and obesity by pubertal stage according to BMI* and two % BF-based references****

Pubertal status†	I	II-III	IV-V	Total	All %
BMI					
85th	21/19	10/15	7/6	38/40 = 78	24.7
95th	15/37	18/14	11/5	44/56 = 100	31.6
McCarthy					
85th	7/12	7 /11	9/4	23/27 5 0	15.8
95th	23/41	22/11	17/5	62/57 = 119	37.6
Mueller					
85th	6/17	4/8	8/4	18/29 = 47	16.2
95th	13/13	20/4	15/3	48/20 = 68	40.1
HBP‡	12/12	8/3	6/0	26/15 = 41	13.0
WC‡	20/43	23/16	12/4	55/63 = 118	37.3

**According with CDC criteria*

***References proposed by MacCarthy et al and Mueller et al.*

†Data expressed in n and Girls/Boys

‡Prevalence of high blood pressure and abdominal obesity

BMI = body mass index, HPB = high blood pressure, WC = waist circumference; 85th = overweight, 95th = obesity

± SD. Differences between the sexes were assessed by independent t-test. The prevalence of overweight and obesity were classified by pubertal stage and were calculated according to BMI in basis of CDC criteria and two % BF-based references proposed by McCarthy et al and Mueller et al. We excluded the children of 7 years old in the classification of Mueller et al because they used a narrower age range (8.5-17.5 year). Statistical relationship between % BF-BMI and % BF-WC were tested by Pearson's correlation coefficient. A p-value less than 0.05 were regarded as significant.

Results

A total of 316 children and teenagers (n = 156 girls, 160 boys) ranging from 7-15 years of age from 360 were studied. Thirty-four participants were excluded by no complete general data and we did not obtain parental consent from twenty children. Average of age for girls and boys were 11.40 ± 2.56 and 11.57 ± 2.43 respectively. There was no significant gender difference in BMI (p = 0.91), while the boys were both taller and present more abdominal obesity but with lower mean % BF (p < 0.00). The relationship between % BF assessed by BIA and the different anthropometric parameters indicators of adiposity (BMI and WC) were significant r = 0.78; p < 0.00 and r = 0.68; p < 0.00 respectively. table I shows the characteristics of the study participants by gender.

In based BMI, the prevalence of overweight (including obesity) in the total sample was 56.3 % and is higher in boys with 30.4 % than girls 25.9 % respectively. The pubertal stage with more prevalent of obesity was status I, being higher in boys. Compared with the prevalence for overweight and obesity determined by McCarthy % BF cutoffs resulted slightly lower (53.4 %) than the BMI. Using Mueller references, the prevalence estimates (56.3 %) in a sample of 289 subjects was equal to the BMI and higher than McCarthy. The concordance of the classifications of overweight and obesity by IMC criteria was really overweight and obesity (Ov-Ob) according to the % BF cutoff, we found that the BMI criteria show a high prevalence for Ov-Ob in boys (12.7 % and 17.7 %) than girls (12 % and 13.9 %) and the % BF cutoff of McCarthy show a less prevalence in the total sample and less overweight in both sexes (girls 7.3 % boys 8.5 %) but presents an increase slight for obesity in girls (19.6 %) and boys (18 %). With Mueller references, show less prevalence of overweight for both sexes (girls 6.2 % boys 10 %) and increase for obesity (girls 16.6 % boys 23.5 %) like McCarthy with respect BMI. Although the %BF of our sample study varied widely we found that the pubertal stage with more cases of Ov-Ob is stage 1 for all classifications. Finally the prevalence of high blood pressure in the entire study was 13 % and is higher in girls (8.2 %) than boys (4.8 %) with same cases in both sexes in stage 1, and the prevalence of abdominal obesity was higher in boys (19.5 %) than girls (17.4 %) and had a higher number of cases in boys in stage 1 (table II).

Discussion

The prevalence of overweight and obesty in children is high in Mexico.[18] Information of the ENSANUT 2006 in the State of Tamaulipas, reported in children aged between 5 and 11 years, in a representative sample of 403 000 school-age children prevalence combined of overweight and obesity of 31.4 % for both sexes, and a prevalence of 38 % for both genders in adolescents, similar to those found in our study.[19] This study forms part of the project conducted by Cornejo et al[20] in Victoria City in children with ages 6 to 16 years, they found (in basis of the CDC criteria) that 21.5 % boys and 19.4 % girls presented overweight (higher than our results) and 16.9 % and 10.5 % obesity, more fat mass in girls from 10 years old (p < 0.05) and less lean mass from 13 years. According to our results we found also difference in the fat mass, being higher in girls than boys (p < 0.005) and lean mass higher in boys (p < 0.00).

Although our results are consistent with data of Cornejo et al in terms of overweight and obesity according with %BF cutoff points proposed by McCarthy et al and Mueller et al, we found that the prevalence of obesity is high in girls than boys. These differences explain that some subjects classified (CDC criteria) as overweight or obese do not have really high adiposity. Although the correlation found between BMI and % BF was significant (r = 0.78), the BMI fails to distinguish between lean body mass and fat.

Thus, the relationships between BMI and body fatness varies according to body composition and proportions, for instance, the percentage of body fat mass is higher in females than in males with similar BMI.[21,22] In addition, the body fat increases until puberty. At puberty sex hormones induce a pronounced sexual dimorphism: males gain proportionately more muscle and lean tissue compared to fat, and females lay down fat as a natural part of the ontogeny of their sexual and reproductive physiology. Along with this, the gonadarche occurs earlier in girls than boys, this reflecting the earlier maturation of the hypothalamic-pituitary-gonadal axis, and girls in late childhood being to show significantly greater total fat mass.[13,23] In the study of Vizmanos et al[24] in boys with pubertal genital stage 2, they found differences in body fat distribution between Spanish boys because of their greater triceps skinfold thickness p = 0.013 and Mexican boys with a greater trunk fat stores (p < 0.01, subscapular and suprailiac skinfolds). In our results observed that the pubertal stage with more cases of overweight and obesity is stage I for all classifications.

In this study it was also found a prevalence of high blood pressure and WC similar to reported by Del Río Navarro et al.[25] The presence of obesity such a major risk for many chronic di-

seases is reflected with the apparition of more cases in stage I of high blood pressure.

In conclusion despite the practical utility of BMI, is important to make clear that it represents the fat mass and fat free mass and can be affected by variations in body water, bone mass and muscle tissue, misclassified the total content of adipose tissue in children with more development muscle. Hence, it is prudent to make diagnosis of obesity based on the measure of percent body fat and do not misclassified subjects. The BIA is a useful technique for studying human body composition, offers the opportunity to move beyond body mass index, do not require much training of the operator, is safe, uncomplicated, relatively inexpensive and the results are immediately available. Our recommendations for decrease the problems of obesity in school population includes a more physical education classes, promotion of consumption of healthy food in schools and promote a nutritional classes. Nowadays, there are no body fat reference curves for Mexican children, future studies should be directed toward the quantitative evaluation of %BF, fat mass and lean mass and establish our own percentile curves.

This study present has some limitations: the cutoff points of %BF were based on the proposed by McCarthy et al but the population studied is in Caucasian children from southern England. Although Mueller et al included subjects recruited from two communities to north of Houston (279 boys and 263 girls) and includes Hispanic children, the centile values of 85th and 95th are much higher and we misclassified subjects with normal percentage of body fat.

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