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Anthropometric indices; predictors of dyslipidemia in children and adolescents from north of Brazil

S. A. Ribas[1] and L. C. Santana da Silva[1,2]

[1]Nutrition Division. Rio de Janeiro State University. Rio de Janeiro. Brazil. [2]Laboratory of inborn errors of metabolism. Institute of Biological Sciences. Federal University of Pará. Belém. Brazil.

Abstract

Introduction: **Atherosclerosis represents a disease that begins in childhood, and alterations in lipid concentration play a fundamental role in the development of this condition.**

Objective: **To evaluate which of the currently applied obesity parameters (the body index mass, the percentage of body fat, the waist circumference and the upper arm fat area) can predict the risk for dyslipidemia in Brazilian children and adolescents.**

Methods: **Cross-sectional study, standardized anthropometric data and lipid profile were collected from 874 subjects between the ages of 6 and 19 years. Logistic regression models were used to evaluate the degree of association between the anthropometric measurements and the lipid profile, controlling for potentially confounding variables, such as age and gender.**

Results: **Individuals with excess body weight, elevated percentage of body fat, waist circumference and upper arm fat above the 90th percentile showed a positive correlation with alterations in the lipid profile. After adjusting for age and income, a body mass index above the 85th percentile and an elevated percentage of body fat were the variables most strongly associated with dyslipidemia in the youngest subjects (odds ratio (OR) = 2.00, $p < 0.001$ and OR = 1.47, $p = 0.014$, respectively). Children (64.5%) and adolescents aged 10-12 years (51.0%) had the highest rates of dyslipidemia.**

Conclusion: **Compared with other variables, such as the percentage of body fat, the body mass index was the best predictor of dyslipidemia in children and adolescents.**

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Key words: *Dyslipidemia. Obesity. Fat distribution. Children. Adolescents.*

Correspondence: Luiz Carlos Santana da Silva.
Laboratory of inborn errors of metabolism.
Institute of Biological Sciences. Federal University of Pará.
Belém. Brazil.
E-mail: ribasnut@yahoo.com.br

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LOS ÍNDICES ANTROPOMÉTRICOS; PREDICTORES DE LA DISLIPIDEMIA EN NIÑOS Y ADOLESCENTES DEL NORTE DE BRASIL

Resumen

Introducción: **La aterosclerosis representa una enfermedad que comienza en la infancia y alteraciones en la concentración de lípidos juegan un papel fundamental en el desarrollo de esta condición.**

Objetivo: **Evaluar cuáles de los parámetros de la obesidad que se aplican actualmente (el índice de masa corporal, el porcentaje de grasa corporal, la circunferencia de la cintura y el área grasa del brazo superior) puede predecir el riesgo de dislipidemia en niños y adolescentes brasileños.**

Métodos: **Estudio transversal, estandarizado de datos antropométricos y perfil lipídico fueron recogidos de 874 pacientes entre las edades de 6 y 19 años. Modelos de regresión logística se utilizaron para evaluar el grado de asociación entre las medidas antropométricas y el perfil lipídico, controlando por variables de confusión potenciales, como la edad y el género.**

Resultados: **Los individuos con exceso de peso corporal, el elevado porcentaje de grasa corporal, circunferencia de la cintura y la grasa del brazo por encima del percentil 90 mostró una correlación positiva con alteraciones en el perfil lipídico. Tras ajustar por edad e ingresos, un índice de masa corporal por encima del percentil 85 y un elevado porcentaje de grasa corporal fueron las variables más fuertemente asociadas con la dislipidemia en los sujetos más pequeños (odds-ratio (OR) = 2,00, p < 0,001 y OR = 1,47, p = 0,014, respectivamente). Los niños (64,5%) y adolescentes de 10-12 años (51,0%) tenían las tasas más altas de la dislipidemia.**

Conclusión: **En comparación con otras variables, tales como el porcentaje de grasa corporal, el índice de masa corporal fue el mejor predictor de la dislipidemia en niños y adolescentes.**

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Palabras clave: *Dislipidemia. Obesidad. Distribución de la grasa. Nniños. Adolescentes.*

Introduction

Childhood obesity is reaching epidemic proportions worldwide,[1] including in Brazil.[2,3] Several reviews have focused on the short-term and long-term consequences of childhood obesity.[4] High body mass index (BMI) is consistently associated with cardiovascular disease risk factors, such as insulin resistance, dyslipidemia, hypertension, and premature atherosclerosis.[5]

In addition, major prospective epidemiologic studies[6-7] have demonstrated that obesity and high levels of low-density lipoprotein cholesterol (LDL-C) in children and adolescents help to predict physiologic arterial changes, such as increased carotid intimal thickness, which may be precursors to early cardiac clinical events in young adults. As a result, the American Academy of Pediatrics Report recently reinforced the importance of cholesterol screening for overweight children (BMI ≥ 85^{th} percentile) over 2 years old[8].

In adults, the BMI is a good parameter for describing overweight and obesity, as it is a simply measured estimate of body fat[5] and predicts cardiovascular risk and mortality.[9] However, in children, it is not known which of the available obesity parameters best predicts the risk of obesity-related diseases and mortality. In addition, although current recommendations are to conduct a cholesterol screening when the BMI ≥ 85^{th} percentile,[8] it is unclear whether this represents an optimal threshold for screening possible lipid alterations in the pediatric population.

A combination of the BMI and other anthropometric indices, including the waist circumference (WC), the percentage of body fat (%BF) and the upper arm fat area (UAFA), is the most widely used approach for diagnosing obesity in epidemiological studies. Despite the relatively straightforward application and usefulness of these measurements in large population studies[10-11] few data that relate the risk of dyslipidemia in children in northeastern Brazil using the BMI and body fat are available.[12]

The aim of this study was to evaluate which of the currently applied obesity parameters (the BMI, the %BF, the WC and the UAFA) can best predict the risk of dyslipidemia in children and adolescents.

Materials and methods

Population and design

Children and adolescents (6-19 y) of both sexes enrolled in public and private elementary, junior high and high schools in the city of Belém, North Brazil, were invited to participate in this cross-sectional study.

Participants with cardiac or metabolic diseases associated with dyslipidemia and obesity or any endocrine disorders, as well as pregnant females and individuals taking lipid-lowering agents, were excluded from the study.

A representative and random sampling of children and adolescents was based on a population of 313,866 students who were enrolled in 293 junior high and high schools (215 public and 78 private) according to a school census from 2008 by the Secretary of Education of the State of Pará , Brazil.

To determine the necessary sample size, we estimated a 3.0% sample error and a 13% prevalence of dyslipidemia in the city of Belém[12] and used a 95% confidence interval. Based on these data, a sample size of 482 individuals was determined. To permit cluster analysis for different age groups (6-9 years, 10-12 years, 13-15 years and 16-19 years), an additional 454 individuals were included for a total of 936 children and adolescents.

All protocol and consent forms were approved by the João de Barros Barreto University Hospital institutional review board, which is part of the Federal University of Pará (UFPA) and written consent from each pupil, was obtained after the study procedures had been fully explained to them. The authors had full access to the data, take responsibility for its integrity and have each read and agreed to the final submission.

Data about each subject's demographic, clinical and socioeconomic status were collected by a team of trained research assistants from May to November of 2005. We recorded each participant's measurements: anthropometric data [weight, height, waist, hip and mid-upper arm circumferences, skinfold thickness (triceps (TSF) and subscapular (SSF) skinfold thickness) and serum lipid concentrations [total cholesterol (TC), LDL-cholesterol (LDL-C), HDL-cholesterol (HDL-C) and triglycerides]. To classify the economic status of pupils' families, the Brazilian Economic Classification Criteria were used from the Brazilian Association of Marketing Research,[13] and family income was determined based on the Brazilian minimum wage at the time (US$110). Pupils' families who had less than one minimum wage per capita were considered lower-income households.

Anthropometry

For analysis, the BMI (in kg/m^2) *z* scores were adjusted for the age and gender for each subject based on the 2007 WHO growth charts[14].Children were classified as overweight if their BMI-for-age z score was > +1 but ≤ +2 (corresponding to > 85th percentile and ≤ 97th percentile) and obese if their BMI-for-age z score > +2 (corresponding to > 97^{th} percentile).

In the absence of a consensus definition of augmented WC in children and adolescents, increased central adiposity was arbitrarily defined as any value above the 90th percentile for the given age-sex group.[15] Skinfold thickness measurements were based on the standard protocols,[15,16] and the percentage of body fat (%BF) was estimated using the equation developed by Slaughter.[16] The cutoffs used to classify the %BF elevation for boys and girls were 20 and 25, respectively.

The residual %BF was estimated based on the UAFA, which was calculated from the MUAC and TSF using the procedure described by Frisancho.[17] The cutoff point for obesity was the 90th percentile for the given age-sex group.

Lipid profile

The subjects fasted for 12 to 14 hours prior to the collection of blood samples at the schools. On the same day after processing, the serum was analyzed in a semi-automated SP 2000 UV Spectrophotometer (Brazil) at the Clinical Analysis Laboratory at UFPA. Total blood cholesterol, triglycerides and HDL-C were determined using enzymatic methods with the appropriate Labtest® reagents. The Friedwald et al.[18] equation (which is recommended by the American Academy of Pediatrics[19]) was used to calculate LDL-C values, as follows: LDL-C = TC-(HDL-C + triglyceride/5). The cut-offs used to assess the serum levels of TC, TG, and HDL-C were based on the values international recommendation.[19]

Statistical analysis

If normally distributed, the results are presented as means (SD); those results not normally distributed are presented as medians (interquartile range). A chi-square test was used for independent samples to compare the prevalence of the assessed variables. Spearman's coefficient rank correlations were used to assess correlations among the tested variables. Concentrations of lipoproteins were compared between overweight and normal weight individuals using a non-parametric Kruskal-Wallis test. The assembly of the logistic model examined how the anthropometric variables (the BMI, the WC, the %BF and the UAFA), which were adjusted for sex, age and income, could predict the probability of risk factors for dyslipidemia. The associations among the anthropometric variables and independent variables were conducted using prevalence odd ratios and confidence intervals. All tests were two-tailed and were 0.05. The analyses were conducted in the SPSS (version 13.0) software package (SPSS Inc., Chicago, IL, USA).

Results

Population characteristics

Sixty-two of the 936 subjects who were initially screened were excluded from the statistical analyses. Disqualification was primarily due to the failure of the subject to satisfy the inclusion criteria (37 subjects), while a further 15 subjects withdrew consent, and 10 refused to provide blood sample at the time of collection.

A total of 874 participants (with a median age of 12.0 years and an interquartile range of 10-15 years and including 452 girls [51.7%]) were studied. There was a prevalence of participants in the class C socioeconomic status (31%). Pupils belonging to the lower socioeconomic class predominated in the public schools (70.5% of pupils), whereas the private schools were dominated by upper class pupils (42.8%). Tables I and II show mean values for the anthropometric indices and median values for the lipoprotein concentrations according to the age- and sex-based classifications of the population study, respectively.

Table I
Mean values by age and sex class for the anthropometric index in population study, Brazil

Variables	*Mean ± standard deviation in age group (years)**					*p*
	Total	*6-10*	*10-13*	*13-16*	*16-20*	
Body index mass (z score)						
Male	19.5 ± 4.1	1.2 ± 2.1	0.7 ± 1.5	0.2 ± 1.1	0.1 ± 1.2	
Female	19.6 ± 3.5	0.9 ± 1.6	0.4 ± 1.0	0.3 ± 0.9	0.1 ± 0.7	< 0.001
Percentage body fat (%)						
Male	17.3 ± 7.9	18.1 ± 7.9	19.7 ± 8.1	17.5 ± 7.6	14.0 ± 6.9	
Female	22.4 ± 6.2†	19.2 ± 6.2	21.1 ± 4.8	23.8 ± 6.0	25.3 ± 6.0	0.012
Waist circumference (cm)						
Male	69.7 ± 11.3	62.5 ± 11.3	68.6 ± 10.6	73.5 ± 9.5	74.7 ± 9.4	
Female	69.2 ± 10.8	60.4 ± 9.2	67.5 ± 9.7	73.8 ± 8.5	74.5 ± 9.8	< 0.001
Upper arm fat area (cm^2)						
Male	15.3 ± 7.4†	11.3 ± 7.6	13.8 ± 7.4	13.8 ± 6.7	12.2 ± 7.7	
Female	12.8 ± 7.3	11.7 ± 6.9	14.0 ± 6.0	17.4 ± 7.5	18.0 ± 6.9	< 0.001

*Sample sizes: 6-9 years – male (n = 112), female (n = 105); 10-12 years – male (n = 105), female (n = 119); 13-15 years – male (n = 100), female (n = 115); 16-19 years – male (n = 105), female (n = 113).
†p < 0.001 Significant difference between sexes.

Table II
Lipid profile concentrations for sex and age of population study, Brazil

Variables[†]	*Median and range in age group (years)**					*p*[‡]
	Total	*6-10*	*10-13*	*13-16*	*16-20*	
Total Cholesterol (mg/dL)						
Male	141 (121-165)	143 (124-165)	143 (121-171)	131 (110-148)	130 (113-148)	< 0.001
Female	136 (118-159)	150 (126-174)	144 (122-170)	133 (117-160)	137 (118-156)	0.007
LDL cholesterol (mg/dL)						
Male	78 (60-95)	84 (63-106)	80 (68-107)	74 (54-91)	72 (59-91)	0.002
Female	82 (61-104)	88 (70-116)	85 (64-106)	75 (57-98)	78 (60-93)	0.002
HDL cholesterol (mg/dL)						
Male	40 (35-47)	42 (37-48)	40 (36-47)	40 (34-47)	38 (33-44)	0.027
Female	41 (35-48)	42 (36-46)	39 (34-46)	41 (36-51)	43 (37-49)	0.041
Triglyceride (mg/dL)						
Male	77 (58-104)	76 (59-99)	77 (57-106)	77 (59-106)	80 (57-105)	0.011
Female	81 (63-104)	80 (65-102)	90 (70-126)	80 (60-98)	79 (61-96)	1.000

*Sample sizes: 6-9 years – male (n = 112), female (n = 105); 10-12 years – male (n = 105), female (n = 119); 13-15 years – male (n = 100), female (n = 115); 16-19 years – male (n = 105), female (n = 113).
[†]LDL: Low-density lipoprotein; HDL: High- density lipoprotein.
[‡]Kruskal-Wallis test.

Nutritional status

From the anthropometric variables, only the UAFA and the %BF showed significant differences between gender (p < 0.001), while all indices varied significantly among the different age groups. In total, 137 (15.7%) of the pupils were overweight [BMI > 85th percentile], and 57 (6.5%) were obese [BMI > 97th percentile]. In addition, 258 (29.5%) of these pupils had elevated %BF values, and 92 (10.1%) and 81 (9.3%) were above the 90th percentile for the WC and the UAFA, respectively. The prevalence of overweight decreased with increasing age groups (p < 0.001). While a significantly larger proportion (p < 0.001) of pupils from private schools were overweight (27.9% *versus* 16.9%) or had an elevated %BF (36.2% *versus* 22.9%) compared with those from public schools, these indices did not vary significantly in relation to per capita income.

Lipid profile

Of the participants, 6.4% were hypercholesterolemic and 15.9% were hypertriglyceridemic, while 5.7% had elevated LDL-C and 28.1% had low HDL-C. In summary, almost half of the subjects (48.5%, or 424) presented some form of dyslipidemia. High rates of dyslipidemia were observed at all age groups: at 6-9 years (64.5%); at 10-12 years (50.9%); at 13-15 years (40.0%) and at 16-19 years (38.5%). Table III shows that there were no significant differences in the percentage of altered values of lipoprotein with respect to gender, type of school or for the anthropometric variables (the WC and the UAFA). In contrast, significant variations were found across age groups and for the anthropometric variables of the BMI and the %BF for most the lipoproteins (table III). Pupils from lower-income households had significantly higher rates of dyslipidemia than pupils from households with higher income. The prevalence of hypercholesterolemia (TC and LDL-C) and hypertriglyceridemia decreased significantly (p < 0.001) with increasing per capita income.

Table IV shows the correlation of anthropometrics indicators between each other and lipid profile according sex. The correlation of anthropometric indicators among lipoproteins by gender shows that the BMI, the WC, the %BF and the UAFA correlated equally with lipid profile for both gender. The majority of the correlations were relatively weak, but significant. None of the anthropometric indicators was correlated with HDL-C. Also, the results showed that there were meaningful, though moderate, correlations among the BMI and other anthropometric variables. The most evident correlation was verified between BMI and WC for males (r = 0.91; p < 0.001) as much as for females (r = 0.89; p < 0.001).

After adjusting for age and income, an analysis of the association between the anthropometric indices and dyslipidemia revealed that pupils with an excess of body weight (a BMI above the 85th percentile) and abnormal body fat distribution (an elevated %BF) had twice the probability of developing dyslipidemia as normal-weight individuals (table V). The odds ratio analysis indicated that there was no significant association between dyslipidemia and either the WC or the UAFA (table V).

Similarly, the WC and the UAFA were not associated systematically with individual dyslipidemic para-

Table III
Percentage of altered values of lipoprotein according to demographic, anthropometric and socioeconomic variables, Brazil

*Variables**	*Total n = 874*	*n*	*Lipoproteins† (mg/dl)*							
			% TC > 170	*p*	*% LDL-C > 130*	*p*	*% HDL-C altered‡*	*p*	*% TG altered§*	*p*
Sex	Female Male	452 422	95 (21.0) 70 (16.6)	0.087	86 (19.0) 64 (15.2)	0.127	121 (26.8) 126 (29.8)	0.35	79 (17.5) 60 (14.2)	0.187
Age group (years)	6-10 10-13 13-16 16-20	217 224 215 218	58 (26.7) 58 (25.9) 26 (12.1) 23 (10.6)	< 0.001	55 (25.3) 49 (21.9) 23 (10.7) 23 (10.6)	< 0.001	86 (39.6) 58 (25.9) 50 (23.3) 52 (23.9)	< 0.001	51 (23.5) 43 (19.2) 21 (9.8) 24 (11.0)	< 0.001
Type of school	Private Public	437 437	92 (21.1) 73 (16.7)	0.102	81 (18.5) 69 (15.8)	0.283	129 (29.5) 117 (26.8)	0.371	69 (15.8) 70 (16.0)	0.923
Family income (MW)‖	< 1 > 1	627 128	144 (23.0) 10 (7.6)	< 0.001	124 (19.8) 12 (9.7)	< 0.001	183 (29.2) 32 (25.2)	0.253	111 (17.7) 14 (10.9)	0.017
BMI (score Z)	< 1Z > 1Z	667 207	103 (15.4) 64 (30.9)	< 0.001	96 (14.4) 56 (26.8)	< 0.001	171 (25.6) 77 (37.1)	0.002	102 (15.3) 46 (22.2)	< 0.001
% BF ¶	Normal Altered	616 258	94 (15.3) 71 (27.5)	< 0.001	93 (15.1) 57 (22.1)	0.012	172 (27.9) 74 (28.7)	0.821	81 (12.1) 76 (29.4)	< 0.001
WC (cm)	< p90 > p90	782 92	142 (18.2) 23 (25)	0.113	131 (16.8) 19 (20.7)	0.348	217 (27.7) 29 (31.5)	0.447	120 (15.3) 19 (20.7)	0.188
UAFA (cm)	< p90 > p90	793 81	145 (18.3) 20 (24.7)	0.162	131 (16.5) 19 (23.5)	0.115	220 (27.7) 26 (32.1)	0.406	121(15.3) 18 (22.2)	0.103

*BMI: Body index mass; %BF: % body fat; WC: Waist circumference; UAFA: Uupper arm fat area.
†TC: Total cholesterol; LDL-C: Hhigh density lipoprotein cholesterol; HDL-C: Low-density lipoprotein cholesterol
‡< 40 mg/dL in children up to 10 years of age, and < 35 mg/dL in those over 10 years;
§> 100 mg/dL in children up to 10 years of age, and > 130 mg/dL in those over 10 years;
‖Minimum wage- (US110); Income not informed by 9 subjects.
¶Body fat altered: > 25 girls or > 20 for boys.

meters (LDL-C, HDL-C and triglycerides), although there was a marginally significant (p = 0.04) relationship between the WC and the TC. Only the BMI was a significant indicator of low HDL-C, whereas both the BMI and the %BF were related significantly to all other dyslipidemic factors. Once adjusted for age and income, the probability of developing dyslipidemia was significant higher for pupils with BMI values above the 85th percentile (OR = 2.0) or %BF values above the 90th percentile (OR = 1.47).

Discussion

The role of obesity, particularly the distribution of BF in the development of cardiovascular disease, especially when associated with dyslipidemia, arterial hypertension and diabetes, has stimulated a great deal of interest and discussion in the medical literature[20]. In this context, it is interesting to note that, in our study, individuals with excess body weights, and WC, %BF and UAFA values above the 90th percentile also presented the most pronounced alterations in their lipid profiles.

We used schoolchildren rather than hospitalized children to evaluate the metabolic derangements associated with overweight. Schools represent an excellent environment for the development of studies on the prevention of obesity and dyslipidemia;[21] these institutions are not only able to exert a direct influence on the knowledge and attitudes of their pupils, but also constitute an important link between family and community. Because of these roles, schools have become one of the principal targets of the efforts by the WHO to prevent chronic, non-transmittable diseases.[22]

To the best of our knowledge, this study presents the first population-based findings of the association between chronic disease risk factors and the BMI and WC values observed in northern Brazilian children and adolescents. In our sample, a high prevalence of dyslipidemia was found in overweight and obese adolescents. In particular, high levels of LDL-C and triglycerides were common in children and adolescent boys and girls who presented either total or central adiposity.

This relationship was most pronounced in pupils with BMI values above the 85th percentile who had twice the chance of developing hypercholesterolemia, 2.5 times the chance of presenting hypertriglyceridemia and 1.5 times the chance of having low HDL-C compared with normal-weight subjects, even after

Table IV
Correlation[1] between anthropometric variables and lipids according to gender, Brazil

AI[†]	BMI (kg/m²)		% body fat		WC (cm)		UAFA (cm²)	
	r	p	r	p	r	p	r	p
Males (n = 422)								
% body fat	0.76	0.000						
WC(cm)	0.81	0.000	0.81	0.000				
UAFA (cm²)	0.79	0.000	0.91	0.000	0.84	0.00		
TC (mg/dL)	0.17	0.00	0.23	0.00	0.15	0.00	0.24	0.00
LDL-c (mg/dL)	0.10	0.03	0.16	0.00	0.07	0.16	0.17	0.00
HDL-c (mg/dL)	-0.09	0.08	-0.06	0.25	-0.08	0.12	-0.06	0.21
TG (mg/dL)	0.26	0.00	0.29	0.00	0.29	0.00	0.28	0.00
Females (n = 452)								
% body fat	0.77	0.000						
WC(cm)	0.73	0.000	0.71	0.000				
UAFA (cm²)	0.79	0.000	0.89	0.000	0.74	0.00		
TC (mg/dL)[‡]	0.12	0.01	0.15	0.00	0.10	0.04	0.15	0.00
LDL-c (mg/dL)	0.11	0.02	0.13	0.01	0.07	0.16	0.14	0.00
HDL-c (mg/dL)	-0.08	0.09	-0.08	0.08	-0.07	0.16	-0.09	0.07
TG (mg/dL)	0.17	0.00	0.18	0.00	0.23	0.00	0.19	0.00

*Adjusted for age and income.
[†]BMI: Body Mass Index; WC: Waist Circumference; UAFA: Upper Arm Fat Area.
[‡]TC: Total cholesterol; LDL-C: High density lipoprotein cholesterol; HDL-C: Low-density lipoprotein cholesterol.

Table V
Adjusted odds ratios for the probability of dyslipidemia and alterations of the different components of the lipid profile[†] in population study, Brazil*

AI[‡]	BMI			% body fat			WC			UAFA		
	OR	(CI 95%)	p	OR	(CI 95%)	p	OR	(CI 95%)	p	OR	(CI 95%)	p
%TC > 170mg/dL	1.98	(1.33-2.92)	0.001	2.25	1.55-3.27	< 0.001	1.73	1.01-2.95	0.052	1.43	0.81-2.50	0.221
LDL-C > 130mg/dL	1.71	2.15-2.57	0.012	1.65	1.12-2.42	0.011	1.42	0.82-2.48	0.212	1.49	0.85-2.63	0.172
HDL-C altered[§]	1.54	1.09-2.19	0.023	1.08	0.76-1.49	0.662	1.25	0.78-2.01	0.351	1.12	0.68-1.86	0.643
TG altered[‖]	2.58	1.73-2.85	< 0.001	2.05	1.39-3.02	< 0.001	1.54	0.89-2.68	0.132	1.51	0.85-2.68	0.162
Dyslipidemia[¶]	2.00	1.41-2.82	< 0.001	1.47	1.08-1.99	0.011	1.56	0.99-2.44	0.062	1.59	0.98-2.59	0.062

*Adjusted for age and income.
[†]TC: Total cholesterol; LDL-C: Low density lipoprotein cholesterol; HDL: High density lipoprotein cholesterol; TG: Triglycerides.
[‡]BMI: Body Mass Index; WC: Waist Circumference; UAFA: Upper Arm Fat Area.
[§]< 40 mg/dL in children up to 10 years of age, and < 35 mg/dL in those over 10 years.
[‖]> 100 mg/dL in children up to 10 years of age, and > 130 mg/dL in those over 10 years.;
[¶]All individuals with an alteration in at least one component of the lipid profile.

adjusting the odds ratio for age and income. These findings are in agreement with a number of previous studies.[3,23,24] While triglyceridemia is not considered a risk factor for coronary disease, an excess of triglycerides may be associated with reduced HDL-C concentrations and increased production of the more atherogenic, dense particles of LDL-C.[25] However, other studies have failed to find a significant relationship between obesity and cholesterol levels (total and LDL) in schoolchildren and did not support the use of the BMI as an indicator of the potential for hypercholesterolemia.[26]

Another important question concerns the ample evidence showing that the location or distribution of excess BF influences the severity of its metabolic complications.[23,27] The present study showed that the pupils with the highest %BF were also those with the greatest alterations in their lipid profiles (LDL-C, TC and triglycerides). In most cases, studies that have investigated the association between %BF and the lipid profiles of children and adolescents have been based on indirect approaches, using separate skinfold (TSF and SSF) measurements, rather than grouping them, as in the present study. This approach hinders comparative analyses. In the study of Maffeis et al.,[28] for example, estimates of the %BF based on skinfold measurements indicated a significant association between this variable and triglyceridemia. This suggests that a relatively modest level of excess adiposity (either central or total) may place an adolescent at increased risk for cardiovascular morbidity.

One of the possible mechanisms explaining the association between obesity and dyslipidemia is the activation of the AMP-dependent kinase pathway, which is induced by an increase in insulin and leptin, and a reduction in the activation of adiponectin, which, in turn, increases the oxidation of fatty acids. In obese children, adiponectin is associated positively with insulin sensitivity and HDL-C concentrations and negatively with triglyceride concentrations.[27]

There is evidence that not only the degree, but also the type of obesity is associated with serum lipoprotein levels in children. A large number of studies have shown that centrally located BF is associated with elevated levels of TC[3] and triglycerides[23,29] and reduced levels of HDL-C.[3,29,30] However, the results of the present study indicated that WC values may be a good method for the assessment of the potential for hypercholesterolemia, given that that the subjects with WC values above the 90th percentile had a 1.7 times greater chance of developing this type of dyslipidemia compared with those below this cutoff point. A similar result was obtained in a study of 3-to-11-year-olds,[28,31] in which WC > the 90th percentile was associated with multiple risk factors.

While few studies have investigated the correlation between upper arm fat and lipid profiles, there are reports of a positive association between the UAFA and specific risk factors for dyslipidemia. In one study by Basit et al.,[27] the UAFA was an indicator of elevated levels of LDL-C. However, in our study, no significant association was found between the UAFA and any of the components of the lipid profile analyzed.

In this study, the BMI was the only anthropometric index to show a significant association with all of the components of the lipid profile (TC, LDL-C, HDL-C and triglycerides) and was the best indicator of hypertriglyceridemia (OR = 2.6, $p < 0.001$). While the families of pupils at private schools had a higher per capita income on average than pupils of public schools, no significant difference in the prevalence of dyslipidemia was found between the two types of schools, which indicates that lipid profiles is not directly influenced by socioeconomic conditions.

These results may reflect a number of different factors, including the relatively higher education level of middle-class parents and their greater access to sources of information, such as the internet, which may help them to appreciate the importance of physical exercise and providing foods with a reduced content of saturated fats and cholesterol for their offspring. In contrast, the Family Budget Research study conducted by the Brazilian Institute for Geography and Statistics (IBGE) between 2002 and 2003 revealed that northern Brazilian families with a per capita income of less than one minimum wage tended to consume relatively small quantities of fruits, green vegetables, and legumes (sources of fiber) but large amounts of cereals, root vegetables, tubers and vegetable oils (rich in carbohydrates) in comparison with families with a per capita income above two minimum wages.[31]

This finding is in contrast to research conducted in other Brazilian cities that revealed that alterations of the lipid profile associated with infantile obesity were more prevalent in economically affluent families and, accordingly, in pupils of private schools.[32,33] By using a wide range of ages, the current study was able to reliably identify the age groups most likely to present dyslipidemia (64.5% of the children and 51.0% of the adolescents 10-12 years of age). The interpretation of cardiovascular risk factors and the choice of cutoff points would have been enhanced in the present study if questions regarding family histories of cardiovascular disease could have been included.[19] Inclusion of family history questions was outside the scope of the present study and was restricted by ethical constraints.

Compared with other variables, such as the %BF and the WC, a child's BMI was the best parameter for evaluating the risk of dyslipidemia in children and adolescents.

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