Jornal de

Pediatria

www.jped.com.br

SOCIEDADE BRASILEIRA
DE PEDIATRIA

ORIGINAL ARTICLE

Hypertriglyceridemic waist phenotype: association with metabolic abnormalities in adolescents☆

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Abstract
Objective: This study aimed to identify the prevalence of hypertriglyceridemic waist (HTW) phenotype, and to evaluate its association with metabolic abnormalities in adolescents of low socioeconomic status.
Method: This was a cross-sectional study with a random sample of 1,076 adolescents between 11 and 17 years, of both genders, from public schools. The participants underwent anthropometric measurements (weight, height, and waist circumference), and levels of total cholesterol, low-density-lipoprotein cholesterol (LDL-C), high-density-lipoprotein cholesterol (HDL-C), non-HDL cholesterol, triglyceride (TG), and fasting glucose were measured. Information regarding the socioeconomic status of the participants' families was obtained. The HTW phenotype was defined by the simultaneous presence of increased waist circumference (≥ 90th percentile for age and gender) and serum triglyceride levels (≥ 100 mg/dL). A logistic regression analysis was used to evaluate the associations of interest.

Results: The prevalence of HTW phenotype was 7.2% among the adolescents, being higher in the presence of obesity (63.4%) and high levels of non-HDL cholesterol (16.6%) and LDL-C (13.7%). The bivariate analysis indicated that, of the metabolic variables, only blood glucose was not associated with the HTW phenotype. Multivariate analysis adjusted for age and gender indicated that the HTW phenotype was positively associated with high non-HDL cholesterol (odds ratio: 7.0; 95% CI: 3.9-12.6) and low HDL-C levels (odds ratio: 2.7; 95% CI: 1.5-4.8).

Conclusions: This study demonstrated that the HTW phenotype was associated with an atherogenic lipid profile, and this phenotype is suggested as a screening tool to identify adolescents with metabolic alterations.

Fenótipo cintura hipergliceridêmica: associação com alterações metabólicas em adolescentes

Resumo

Objetivo: O presente estudo objetivou identificar a prevalência do fenótipo cintura hiper-trigliceridêmica (CHT) e avaliar sua associação com alterações metabólicas em adolescentes de baixa condição econômica.

Método: Estudo transversal com amostra probabilística de 1.076 adolescentes entre 11 e 17 anos, de ambos os sexos, estudantes de escolas públicas. Os participantes foram submetidos à avaliação antropométrica (peso, altura e circunferência da cintura) e à dosagem dos níveis de colesterol total, LDL-C, HDL-C, colesterol não HDL, triglicérides (TG) e glicemia de jejum. Foram obtidas informações referentes às condições econômicas das famílias dos participantes. O fenótipo CHT foi definido pela presença simultânea da circunferência da cintura aumentada (≥ percentil 90 por idade e sexo) e dos níveis séricos de triglicérides elevados (≥ 100 mg/dL). A análise de regressão logística foi utilizada para avaliação das associações de interesse.

Resultados: A prevalência do fenótipo CHT foi de 7,2% entre os adolescentes, sendo mais elevada na presença de obesidade (63,4%), do colesterol não HDL (16,6%) e do LDL-C (13,7%) altos. A análise bivariada indicou que, das variáveis metabólicas, apenas a glicemia não se associou ao fenótipo CHT. A análise multivariada, ajustada por sexo e idade, indicou que o fenótipo CHT se associou positivamente com o colesterol não HDL alto (*odds ratio*, 7,0; IC95% 3,9-12,6) e com o HDL-C baixo (*odds ratio*, 2,7; IC95%, 1,5-4,8).

Conclusões: Este estudo mostrou que o fenótipo CHT se associou com um perfil lipídico aterogênico e sugere esse fenótipo como uma ferramenta de *screening* que pode ser utilizada para identificar adolescentes com alterações metabólicas.

Introduction

Cardiovascular diseases are the leading cause of death in developed and developing countries.[1] In Brazil, they are a leading cause of death in all regions.[2] Excess body weight, especially in the abdominal region, is a major risk factor for cardiovascular disease, and is associated with a set of metabolic abnormalities such as dyslipidemia, hypertension, insulin resistance, hyperinsulinemia, and diabetes.[3,4]

The hypertriglyceridemic waist (HTW) phenotype is represented by the simultaneous presence of elevated serum triglycerides and increased waist circumference. This phenotype has been proposed as a diagnostic tool and predictor of the atherogenic metabolic triad (hyperinsulinemia, elevated levels of apolipoprotein B, and increased concentrations of patern B subtype of low-density lipoprotein [LDL-C]). It has also been proposed as an alternative to the diagnosis of metabolic syndrome, especially as an indicator of cardiovascular and metabolic risk associated with visceral obesity.[5-8]

The pioneering study by Lemieux et al. reported that the HTW phenotype had a high correlation with the atherogenic metabolic triad, and was able to predict it. In that study, male subjects with elevated values of waist circumference and triglycerides showed increased risk for coronary artery disease when compared to those with normal levels. It was also observed that men with the HTW phenotype were 3.6 times more likely to have coronary artery disease.[8] Results from other studies conducted with both genders corroborated their findings.[5,7,9-12]

In Brazil, cardiovascular diseases are the leading cause of morbidity and mortality, and lately they have been shown to affect young individuals, causing a significant reduction of productive life.[2] Thus, early detection of metabolic alterations may contribute to the development of preventive health programs, aiming to preclude young

people from developing early cardiovascular disease and the associated consequences.

Considering the scarcity of data on the HTW phenotype in the young population, especially in Brazil, this study aimed to identify the prevalence of the HTW phenotype and its association with metabolic abnormalities in adolescents from public schools in a city in Northeastern Brazil.

Method

Study design and population

This was a cross-sectional study, part of a larger study conducted with students aged 11 to 17 years, of both genders, from public schools of the city of Salvador, state of Bahia, Northeastern Brazil. Data from the school census were used, provided by the Education Secretariat of the State of Bahia. The sample size calculation was based on a population of 77,873 students, adopting the two-stage cluster sampling technique, represented by schools and classes.

This investigation was designed to meet several goals. In order to specifically investigate the HTW phenotype, the sampling design was defined based on a prevalence of 6.4% for the HTW phenotype,[13] with 98% confidence and maximum permissible error of 2%, estimating a minimum number of 1,068 adolescents in the sample. This same sample size has 95% power to detect associations between HDL-C and non-HDL-C with HTW phenotype, with a significance level of 5%.

Twenty-three of the 207 public schools in Salvador were randomly selected; three classes were randomly selected per school, totaling 1,216 assessed adolescents. Of these, 1,076 had complete information for this study, exceeding the minimum necessary for the proposed objectives.

Pregnant women, nursing mothers, and adolescents with physical disabilities that prevented anthropometric assessments were excluded. All adolescents had written permission from their parents or legal guardians to participate, and those who showed alterations were referred to a multidisciplinary health care team. The study was approved by the Ethics Committee of the Escola de Nutrição of the Universidade Federal da Bahia (08/09). Data collection was carried out in the school environment, by qualified and previously trained personnel, from July to December of 2009.

Anthropometric assessment

Anthropometric measurements were systematically collected.[14] Weight was measured using a Master® portable digital scale, and height was assessed through a Leicester Height Measure® portable stadiometer, assuming a maximum variation of 100 g and 0.5 cm, respectively, for weight and height. Body mass index (BMI) was used for the diagnosis of anthropometric status, adopting the percentiles for age and gender proposed by the World Health Organization:[15] underweight (< 3rd percentile), appropriate (3rd percentile ≤ BMI ≤ 85th percentile), overweight (85th ≤ BMI ≤ 97th percentile), and obesity (> 97th percentile). For the analysis, the following categories were considered: adequate anthropometric status (underweight and appropriate weight – reference category), overweight, and obesity.

Waist circumference was measured at the midpoint between the iliac crest and the outer surface of the last rib. Measurements were performed in duplicate by two independent examiners, accepting variations of 0.5 cm, and considering the mean between the values. Waist circumference was considered increased when the measured value was ≥ 90th percentile according to age and gender[16,17] of the sample population.

Biochemical assessment

After a 12-hour fast, 5 mL of blood was collected from the adolescents, intravenously, in an appropriate environment at school. The samples were properly stored and transported to the Central Laboratory of the Complexo Hospitalar Universitário Professor Edgard Santos, where they were analyzed. Serum levels of total cholesterol (TC), high-density lipoprotein (HDL), and triglycerides were determined by enzymatic methods, LDL-C was calculated using Friedewald's formula when triglycerides were lower than 400 mg/dL. The following values were considered adequate: total cholesterol < 150 mg/dL, LDL-C < 100 mg/dL, HDL-C ≥ 45 mg/dL, and triglycerides < 100 mg/dL.[18] For the non-HDL cholesterol, adequate values were < 123 mg/dL.[19] Fasting glucose was determined by the enzymatic method, with adequate values < 100 mg/dL.[20]

Hypertriglyceridemic waist phenotype

The HTW phenotype was defined by the simultaneous presence of increased waist circumference (≥ 90th percentile for age and gender of the sample population) and serum triglyceride levels (≥ 100 mg/dL).[4,13]

Socioeconomic status

Information on the socioeconomic status was provided by the adolescents' parents or guardians. To characterize the socioeconomic conditions, the Brazilian Economic Classification Criterion was used, which considers the possession of household goods and educational level of the household head, using a rating scale that classifies individuals into categories from A to E, starting with the highest purchasing power.[21] The adolescents were stratified into the categories C, D, and E, and were grouped as better socioeconomic status (categories C and D-reference) and worse socioeconomic status (category E). No individuals were identified in the higher income categories (A and B).

Statistical analysis

The population was characterized through descriptive analysis, using proportion for categorical data and mean (standard deviation) for continuous variables. Logistic regression was used to estimate odds ratios (OR) and their respective 95% confidence interval (95% CI) to evaluate the associations of interest, using two-tailed tests and adopting

Table 1 Percentiles of waist circumference (cm) by age and gender of adolescents (11 to 17 years) from public schools, Salvador, BA, Brazil, 2009-2010.

	Percentile for the male gender				Percentile for the female gender			
Age (y)	n	50	75	90	n	50	75	90
11	17	66.20	70.38	74.85	32	63.00	67.37	83.65
12	76	62.35	68.11	77.20	129	65.00	69.90	79.75
13	75	64.35	70.00	82.24	178	66.00	71.60	80.46
14	107	67.00	72.15	81.96	156	67.05	70.98	78.44
15	69	69.55	75.50	83.00	79	68.20	72.50	79.50
16	44	70.20	75.50	82.52	48	70.50	75.00	85.89
17	39	71.70	75.45	78.60	27	68.20	76.00	84.87

Table 2 Metabolic characteristics according to the hypertriglyceridemic waist (HTW) phenotype of adolescents (11 to 17 years) from public schools, Salvador, BA, Brazil, 2009-2010.

Metabolic variables	n	Mean levels (SD[a])			
		Total	HTW(−)	HTW(+)	p*
Total cholesterol (mg/dL)	1.076	158.6 (1.2)	156.6 (1.2)	183.6 (4.8)	< 0.0001
LDL-C (mg/dL)	1.074	89.4 (1.0)	87.9 (1.0)	109.2 (4.3)	< 0.0001
HDL-C (mg/dL)	1.076	48.4 (0.3)	48.9 (0.4)	42.9 (0.8)	< 0.0001
Non-HDL cholesterol (mg/dL)	1.076	110.1 (1.2)	107.7 (1.1)	140.7 (4.7)	< 0.0001
Triglycerides (mg/dL)	1.076	102.4 (1.7)	97.2 (1.5)	170.0 (11.2)	< 0.0001
Glycemia (mg/dL)	1.076	90.2 (0.3)	90.2 (0.3)	90.2 (0.9)	0.958

HDL-C, high-density lipoprotein cholesterol; HTW(−), absent hypertriglyceridemic waist phenotype; HTW(+), present hypertriglyceridemic waist phenotype; LDL-C, low-density lipoprotein cholesterol; non-HDL, non-high density lipoprotein; SD, standard deviation.
HTW phenotype was defined by the simultaneous presence of increased waist circumference (≥ 90th percentile for age and gender) and high levels of triglycerides (≥ 100 mg/dL).
*Student's t-test.

a significance level of 5%. Continuous variables were categorized and included in bivariate and multivariate models. The associations between the response variable and exposure variables were initially estimated using bivariate logistic regression.

Variables with p-value ≤ 0.20 in this analysis were selected for further multivariate analysis. Only those variables with p < 0.05 remained in the final explanatory model. Statistical analyses were adjusted for the complex sample design, by using SVY commands of Stata release 10.0.

Results

Most of the students were females (59.7%), with a mean age of 14.4 (1.5) years. Regarding anthropometric status, the majority were adequate (75.8%), followed by underweight (7.9%), overweight (9.8%), and obese (6.5%). Table 1 shows the waist circumference percentiles for age and gender of the studied adolescents. The 90th percentile was considered increased waist circumference.

The prevalence of HTW phenotype was 7.2% among the adolescents in this study. The prevalence of isolated

components of the HTW phenotype was 11.3% and 42.5% for increased waist circumference and high serum triglyceride levels, respectively.

A higher prevalence of HTW phenotype was observed at age 11 years for both genders (males 15.0%, females 13.1%). In males, a higher prevalence of HTW phenotype was identified up to 14 years of age. At ages 15 and 16 years, inversions in the prevalence of HTW phenotype were observed, with higher values found in females.

After 16 years of age, the prevalence of HTW phenotype decreased in both genders (males 2.7%, females 3.1%). It is noteworthy that no statistically significant difference (p > 0.05, Fisher's exact test) was observed for these associations (data not shown in table).

The mean values of metabolic parameters are shown in Table 2. Adolescents with HTW phenotype presented significantly higher mean values of total cholesterol, LDL-C, and non-HDL cholesterol, as well as lower mean HDL-C levels, when compared to those without the HTW phenotype. There was no significant difference in mean glucose levels between adolescents with and without the HTW phenotype.

The prevalence of HTW phenotype was higher among obese adolescents (63.4%), who presented high levels of total

Table 3 Prevalence of the hypertriglyceridemic waist (HTW) phenotype and individual components of adolescents (11 to 17 years) from public schools, Salvador, BA, Brazil, 2009-2010.

Variables	Total	Increased WC[a]		High TG[b]		HTW[c]	
	n (%)	(%)	p[d]	%	p[d]	%	p[d]
Gender							
Male	427 (40.3)	10.2	0.399	41.7	0.725	7.9	0.547
Female	649 (59.7)	12.1		43.0		6.8	
Age (years)							
< 12	49 (4.1)	13.7	0.894	48.9	0.651	13.7	0.297
12-16	869 (78.2)	11.1		42.6		7.2	
≥ 16	158 (17.8)	11.7		40.4		5.8	
Anthropometric status[e]							
Adequate	908 (83.7)	1.6	< 0.0001	39.9	0.0005	0.7	< 0.0001
Overweight	103 (9.8)	40.9		49.2		25.8	
Obesity	65 (6.5)	91.8		65.8		63.4	
Socioeconomic class							
C	45 (5.3)	6.5	0.157	44.6	0.659	3.1	0.601
D	456 (46.5)	13.4		41.2		7.7	
E	483 (48.2)	9.2		44.8		7.1	
Total cholesterol							
Adequate (< 150 mg/dL)	495 (44.9)	6.5	0.0001	28.2	< 0.0001	3.3	< 0.0001
High (≥ 150 mg/dL)	581 (55.1)	15.2		54.1		10.5	
LDL-C							
Adequate (< 100 mg/dL)	733 (66.9)	6.9	< 0.0001	38.1	0.0005	3.8	< 0.0001
High (≥ 100 mg/dL)	341 (33.1)	19.6		50.9		13.7	
HDL-C							
Adequate (≥ 45 mg/dL)	660 (62.7)	8.8	0.005	38.3	0.002	4.9	0.001
Low (< 45 mg/dL)	416 (37.3)	15.6		49.5		11.3	
Non-HDL cholesterol							
Adequate (< 123 mg/dL)	330 (68.1)	6.4	< 0.0001	34.2	< 0.0001	2.9	< 0.0001
High (≥ 123 mg/dL)	746 (31.9)	21.9		60.1		16.6	
Glycemia							
Adequate (< 100 mg/dL)	905 (86.2)	11.5	0.600	41.8	0.291	7.3	0.946
High (≥ 100 mg/dL)	171 (13.8)	10.0		46.8		7.1	

HDL-C, high-density lipoprotein cholesterol; HTW, hypertriglyceridemic waist phenotype; LDL-C, low-density lipoprotein cholesterol; non-HDL, non-high density lipoprotein; TG, triglyceride; WC, waist circumference.
[a]Waist circumference ≥ 90th percentile for age and gender.
[b]Triglycerides ≥ 100 mg/dL.
[c]HTW phenotype was defined by the simultaneous presence of increased waist circumference (≥ 90th percentile for age and gender) and high triglycerides (≥ 100 mg/dL).
[d]Chi-squared test.
[e]Underweight and adequate weight (≤ 85th percentile); overweight (> 85th percentile and ≤ 97th), obesity (> 97th percentile).

cholesterol (10.5%), high LDL-C (13.7%), low HDL-C (11.3%), and high non-HDL cholesterol levels (16.6%) (Table 3).

The results of the bivariate analysis indicated that the HTW phenotype was associated with high non-HDL cholesterol (OR = 6.6, 95% CI: 3.8-11.7), LDL-C (OR = 4.0, 95% CI: 2.3-7.0), total cholesterol (OR = 3.5, 95% CI: 1.9-6.4), and low HDL-C (OR = 2.5, 95% CI: 1.4-4.4). Among the metabolic variables, only fasting glucose was not associated with HTW phenotype. The result of the multivariate analysis, adjusted for gender and age, indicated that the HTW phenotype was positively associated with high non-HDL cholesterol (OR = 7.0, 95% CI: 3.9-12.6) and low HDL-C levels (OR = 2.7, 95% CI: 1.5-4.8) (Table 4).

Discussion

This study represents the first study in Brazil that used a representative sample of adolescents of both genders, who attended public schools in a state capital in Northeastern Brazil. In this study, the prevalence of HTW phenotype was 7.2%, indicating that it is an important clinical event among the studied adolescents. It is also noteworthy the higher occurrence of the HTW phenotype among adolescents with high levels of non-HDL cholesterol and low levels of HDL-C, when compared with those with adequate levels of these markers of cardiovascular risk.

Table 4 Crude ($_{crude}$OR) and adjusted ($_{adjusted}$OR) odds ratio for the association between variables and hypertriglyceridemic waist phenotype of adolescents (11 to 17 years) from public schools, Salvador, BA, Brazil, 2009-2010.

Variables	$_{crude}$OR (95% CI)	$_{adjusted}$OR[a] (95% CI)
Gender		
Male	1	–
Female	1.2 (0.7-2.0)	
Age (years)		
< 12	1	
12-16	2.0 (0.8-5.5)	–
≥ 16	0.8 (0.4-1.8)	
Socioeconomic status		
Higher socioeconomic status	1	–
Lower socioeconomic status	0.9 (0.6-1.5)	
Total cholesterol		
Adequate (< 150 mg/dL)	1	–
High (≥ 150 mg/dL)	3.5 (1.9-6.4)	
LDL-C		
Adequate (< 100 mg/dL)	1	
High (≥ 100 mg/dL)	4.0 (2.3-7.0)	
HDL-C		
Adequate (≥ 45 mg/dL)	1	1
Low (< 45 mg/dL)	2.5 (1.4-4.4)	2.7 (1.5-4.8)
Non-HDL cholesterol		
Adequate (< 123 mg/dL)	1	1
High (≥ 123 mg/dL)	6.6 (3.8-11.7)	7.0 (3.9-12.6)
Glycemia		
Adequate (< 100 mg/dL)	1	
High (≥ 100 mg/dL)	1.0 (0.5-2.0)	

95% CI, 95% confidence interval; HDL-C, high-density lipoprotein cholesterol; LDL-C low-density lipoprotein cholesterol; non-HDL, non-high-density lipoprotein cholesterol.
[a] Adjusted for gender and age.

The prevalence of HTW phenotype in adolescents in this study was similar to those identified in adolescents from Tehran, Iran (6.4%),[13] and in children and adolescents in Iran (8.5%).[22] The only study on HTW phenotype in adolescents in Brazil was performed by Pereira[4] in Viçosa, state of Minas Gerais, and found a prevalence of 2.6% for HTW phenotype in female adolescents aged 14 to 19 years. This differs from the present findings, which identified a higher prevalence for the same gender and age range (7.3%).

It is possible that the differences in the prevalence of HTW phenotype in the studies performed in Brazil and in other regions of the world are due to the cutoffs used, as reference values for waist circumference and triglyceride levels may differ depending on ethnicity and lifestyles, which alters the accumulation of abdominal fat.[3,4,23] Another aspect to be considered regarding the waist circumference measurement is the variation, observed in several studies, in the anatomical location used for this measurement.[3,4,13] Thus, the lack of standardization for worldwide use of serum triglycerides and mainly for waist circumference measurement makes comparison between studies difficult.

It is noteworthy that the prevalence of hypertriglyceridemia in adolescents in this study (42.5%) was higher than that found in other studies performed in Brazil, which ranged from 13.95 to 35.3%.[24,25] This is a disturbing fact, as high

serum triglycerides levels are considered an independent risk factor for cardiovascular disease.[8,24]

Data from this study indicate a positive and significant association between the HTW phenotype and an atherogenic lipid profile, with no association with fasting glucose. These results corroborate those by Esmaillzadeh et al.,[13] who showed that HTW phenotype was positively associated with high blood pressure, total cholesterol, LDL-C, and low HDL-C levels, but not with fasting glycemia. The study by Alavian et al. also indicated that the prevalence of alterations in the lipid profile was higher among Iranian adolescents with HTW phenotype, a result similar to that observed among Brazilian adolescents. Conversely, the present study showed no association between HTW phenotype and fasting glucose, as observed in Iranian children and adolescents,[22] although the prevalence of hyperglycemia was high (13.8%).

Studies performed in adolescents from different regions of Brazil have identified a hyperglycemia prevalence ranging from 0.5% to 24.3%.[24,26] This fact deserves attention, as glycemia is related to obesity and cardiovascular diseases, showing late alterations.[4]

The HTW phenotype may represent a marker of excess visceral fat, the most common cause of insulin resistance,

which is considered an important etiopathogenic factor for the development of glucose intolerance and hyperinsulinemia.[7,23,27] It is noteworthy that individuals with visceral obesity also tend to have hypertriglyceridemia and low HDL-C, as well as elevated small, dense particles of LDL-C and elevated apolipoprotein B concentrations, characterizing an atherogenic lipid profile, although many times serum concentrations of LDL-C are normal.[23] Another variable related to the atherogenic lipid profile is high non-HDL cholesterol levels, which includes all cholesterols that have triglyceride-rich lipoproteins in their composition, potentially atherogenic.[19,28] The results of Bos et al. showed that non-HDL cholesterol increased the risk associated with the presence of HTW phenotype by 50%.[28]

It is believed that, in the presence of visceral obesity, the lipolytic activity in visceral adipocytes is high, resulting in an increased release of free fatty acids and consequent cellular accumulation, mainly in the liver, muscles, and pancreas. Excess free fatty acids in the liver provide a substrate for the production of hepatic triglycerides and triglyceride-rich lipoproteins in the circulation.[13,23,29] Furthermore, excess circulating free fatty acids can induce insulin resistance and hyperinsulinemia, due to glucose uptake inhibition and to oxidation by muscles and other organs.[13] Thus, individuals with visceral obesity have important metabolic alterations that can be diagnosed early through the HTW phenotype.

Studies on the HTW phenotype in childhood and adolescence are scarce. However, several investigations have been performed in European, Canadian, and North-American adult populations. The results of these studies have indicated a positive association between HTW phenotype and higher mean values of total cholesterol, LDL-C, and non-HDL cholesterol, and lower HDL-C levels,[5-7,9-11] corroborating the findings of other studies involving younger age ranges, possibly indicating that the phenomenon occurs both in adolescence and in adulthood.

Studies with a cohort design may indicate whether the event begins in childhood and/or adolescence and continues into adulthood, as it occurs with atherosclerotic plaque formation.[30] The available evidence is consistent for the association between HTW phenotype and atherogenic metabolic abnormalities and cardiovascular risk. This evidence can sustain the position of many investigators that the HTW phenotype can be used as an accurate and inexpensive screening tool to identify individuals at cardiometabolic risk, who would benefit from proper prevention and/or early treatment.[6,7,9,11,22] Moreover, information is consistent for the indication and use of HTW phenotype as a tool of equal or greater importance than the current diagnostic criteria for metabolic syndrome for the identification of cardiovascular risk.[7,10,12]

The HTW phenotype is a practical and easily applied tool, as its use depends only on waist circumference and fasting triglycerides measurements. Waist circumference is an anthropometric indicator strongly associated with abdominal obesity, predicting hyperinsulinemia and elevated levels of apolipoprotein B, whereas triglyceride concentrations have the power to predict the small, dense particles of LDL-C,[7,8,11] which cannot be assessed by LDL-C determination, only through sophisticated and expensive methods. Thus, the HTW phenotype predicts the atherogenic metabolic triad, nontraditional risk factors for coronary artery disease, which have been considered better predictors of cardiovascular disease.[6,8,9]

Some limitations of this study should be considered. The first concerns the cross-sectional design, which precludes the establishment of a cause-and-effect association between events; however, it raises several questions that need further research to be answered. The second is the lack of information on some of the risk factors for cardiovascular disease, such as hypertension, alcohol consumption, smoking, physical activity, and inflammatory markers and cardiovascular risk protectors that were not collected in this study. The third is the lack of sample population of higher economic status, making it impossible to compare the different strata. Additionally, the lack of standardization of available classification criteria for HTW phenotype, mainly in the younger population, must be mentioned. However, the results of this study are reinforced by the biological plausibility and similar results reported by prospective studies,[9,11,12] supporting the theory that the HTW phenotype is a good risk indicator for cardiovascular disease morbimortality.

Thus, the clinical results of this study supplement others, adding evidence that the HTW phenotype is associated with an atherogenic lipid profile, contributing to support the use of HTW phenotype in clinical and epidemiological studies due to its ease of application, practicality, accuracy, and low cost. Hence, it can provide early identification of children, adolescents, and adults who may be at metabolic risk, and is very useful in primary care, guiding the adoption of primary prevention measures. It is emphasized, therefore, that physicians and other professionals working in primary care should be instructed in order to identify these individuals early and manage them adequately, regarding both prevention and therapeutics.

Conflicts of interest

The authors have no conflicts of interest to declare.

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