Artículo Original / Original Article

Factors associated with the lipid profile of adolescents

Factores asociados con el perfil lipídico de adolescentes

ABSTRACT

There is a high prevalence of dyslipidemia in adolescence. The aim of this study was to determine the lipid profile of adolescents and associated factors. We conducted a cross-sectional study with male and female adolescents from public and private schools in Teresina, aged 14 to 19 years. Body mass index (BMI) z-score was obtained and adjusted for age, in addition to waist circumference (WC) percentile values. Lipid profile was determined by enzymatic colorimetric method; LDL-C was calculated. The statistical tests Mann-Whitney U, Student's t, and odds ratio were used. The sample was comprised of 327 adolescents with a mean age of 16.5 years, 59.6% were female and 65.7% from public schools. The prevalence of dyslipidemia was 85.6%, especially hypoalphalipoproteinemia. TG levels were significantly higher and HDL levels were lower among participants who attended public schools ($P < 0.05$). BMI and WC were associated with dyslipidemia; a higher mean BMI and overweight was observed in girls with dyslipidemia. In the adjusted regression, being from a public school increased the odds for low HDL-C and dyslipidemia, while overall higher BMI and abdominal excess weight represented a risk for higher triglycerides. Thus, overweight increased the chances of hypertriglyceridemia and studying in a public school increased the odds for dyslipidemia and hypoalphalipoproteinemia.

Keywords: Adolescent; Dyslipidemia; Hypertriglyceridemia; Obesity; Obesity, abdominal.

RESUMEN

Las dislipidemias tienen una elevada prevalencia en la adolescencia. Nuestro objetivo fue determinar el perfil lipídico de adolescentes y sus factores asociados. Realizamos un estudio transversal que abarcó adolescentes de escuelas públicas y privadas de Teresina, con edad entre 14 y 19 años, de los dos sexos. El índice de masa corporal (score-z, IMC-Z) se obtuvo conforme a la edad, y la circunferencia de la cintura (CC) en percentil. La determinación del perfil lipídico se realizó por método enzimático colorimétrico; LDL-C fue calculado. Las pruebas estadísticas Mann-Whitney U, T de Student y odds ratio fueron utilizadas. La muestra

comprendió 327 adolescentes con edad media de 16,5 años, siendo 59,6% del sexo femenino y el 65,7% de escuelas públicas. La prevalencia de dislipidemia fue 85,6%, destacándose la hipo-alfa-lipoproteinemia. Los niveles de TG fueron significativamente mayores y los de HDL menores en las escuelas públicas ($P < 0,05$). Al asociar IMC y CC con dislipidemia, se observó mayores valores medios de IMC en las niñas con dislipidemia y sobrepeso. En la regresión ajustada, ser de escuela pública aumentó las posibilidades de bajo HDL-C y dislipidemia, mientras que el exceso de peso global y abdominal fueron factores de riesgo de cambios en los triglicéridos. Así, el exceso de peso elevó las posibilidades de hipertrigliceridemia, y estudiar en escuela pública elevó las posibilidades de dislipidemia

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e hipo-alfa-lipoproteinemia.

Palabras clave: Adolescente; Dislipidemia; Hipertrigliceridemia; Obesidad; Obesidad abdominal.

INTRODUCTION

Dyslipidemia has become an important public health problem in many countries because of its high prevalence and due to its causal relationship with chronic non-communicable diseases. At early ages, it may cause an atherosclerotic process, and contribute to the development of cardiovascular disease in adulthood. In Brazil, research shows a high prevalence of lipid disorders in adolescence¹⁻⁴.

The increased trend of obesity in adolescence, as it has occurred in developed countries, has been related to increased prevalence of lipid disorders⁵. In Brazil, there is a lack of studies of national scope that show dyslipidemia in adolescents. The Study of Cardiovascular Risks in Adolescents (ERICA) showed that the changes with highest prevalence in Brazilian adolescents were HDL-C reduction, hypercholesterolemia (total cholesterol-TC) and hypertriglyceridemia¹. In this sense, the early identification of dyslipidemia and associated factors may improve long-term health outcomes^{6,7}.

Overweight, physical inactivity, inadequate diet and improper lifestyle habits in general, in addition to secondary causes such as diabetes mellitus, hypothyroidism, among others, are involved in the onset of dyslipidemia⁸⁻¹¹.

Among the factors associated with dyslipidemia, overweight is highlighted. An exaggerated expansion of adipose tissue, typical of obesity, causes deregulation of adipocytokines, which are substances produced in this tissue, subsequently triggering low-grade chronic inflammation and altering lipid homeostasis. More specifically, the increase of intra-abdominal fat is a major contributor to the development of changes in serum lipids^{4,12,13}.

In this perspective, attention must be drawn to the importance of controlling risk factors that lead to the development of lipid changes in adolescence, reducing the risk of development of chronic non-communicable diseases. In view of the above, the present study aimed to determine the lipid profile of adolescents and associated factors.

MATERIALS AND METHODS

This was a cross-sectional study, part of the project entitled "Saúde na escola: diagnóstico situacional no ensino médio" ("Health at school: situational diagnosis in high school"), of the Post-Graduation Course in Health and Community of the Federal University of Piauí (UFPI). This research included high school students, aged 14 to 19 years, from the public and private education networks of the municipality of Teresina-PI.

One hundred sixty-nine schools with regular high school courses in the city of Teresina were listed for inclusion in the study, totaling 101 publics and 68 private institutions. They were organized according to the type of management (public or private), the four geographical areas in which the city was divided, and for size as small, medium and large,

so that a public and a private school of each size could be drawn for each geographical area, totaling 24 schools (12 publics and 12 private). After that, students were drawn from each school.

The sample of students was a stratified probabilistic sample, proportional to the size of the four geographic areas in which Teresina was divided, to the type of management and size of the school, in addition to grade, gender, and age, in that order.

The calculation of the minimum required sample size was performed using the Epi Info 6.04d program (Centers for Disease Control and Prevention, Atlanta, USA). According to the School Census data of 2014¹⁴, there were 40,136 high school students in public (state) and private schools. We adopted a 95% confidence interval, prevalence of 17.1% overweight¹⁵, accuracy of 5%, design effect of 1.4¹⁶ and significance level of 5%¹⁷. The design effect of 1.4 adopted was aimed at correcting the sample size by 40%, necessary to keep the desired precision of a stratified sample. With this, the minimum required sample size was 316 adolescents. Due to the losses of cases that could occur, 10% more were drawn from the sample of each school, using the same selection criteria, making up a sample of 348 adolescents.

The anthropometric data of weight and height were obtained according to Cameron¹⁸ and Jelliffe & Jelliffe¹⁹, and waist circumference (WC) according to Callaway et al. (1988), at the midpoint between the last rib and the iliac crest²⁰. Weight (in kilograms) was measured using a portable electronic scale (Seca®) with 100g accuracy and height (cm) was measured using a Seca® stadiometer with 0.1 cm accuracy. WC was measured using an inelastic tape measure (Seca®, model 201, Hamburg, Germany) with 0.1 cm accuracy, with the Fredriks et al.²¹ curve being used as a reference, since that study covers the entire age range of the present study. Thus, abdominal obesity was considered as WC > 90th percentile, according to gender and age. All evaluations were performed in triplicate.

Body mass index (BMI) was obtained by the ratio between weight (kg) and squared height (m²), being expressed in z-score, according to the curves of the World Health Organization (WHO)²². In the nutritional diagnosis, low and normal weight were combined, and the categories of overweight and obesity corresponded to the overweight group. The following classification was considered according to z-score values: severe thinness, z-score values < -3; thinness, z-score values ≥ -3 and < -2; normal weight, z-score values ≥ -1 and ≤ +1; overweight, z-score values > +1 and ≤ +2; obesity, z-score values > +2 and ≤ +3; and severe obesity, z-score values > +3.

For serum lipid analyses, 5 mL of venous blood was collected from the adolescents after a fast of at least 12 hours. Disposable plastic syringes and sterile, disposable, stainless steel needles were used. The material was then placed in Vacuette® tubes without anticoagulant. The concentrations of total cholesterol (TC), HDL-C and triglycerides (TG) were determined according to enzymatic colorimetric method

using Labtest® kits. LDL-C was calculated by the formula of Friedwald et al.²³, valid for TG values below 400 mg/dL. The analyses were performed in the Laboratory of the Nucleus of Research in Medicinal Plants of the Post-Graduation Program in Pharmacology of UFPI. The cut-off values for serum lipids of the V Brazilian Guideline for Dyslipidemia and Prevention of Atherosclerosis²⁴ were used, whose reference values are: TC < 150, TG < 100 mg/dL, and LDL-c < 100 mg/dL. For HDL-C, the reference value of the National Cholesterol Education Program²⁵ was used, which is ≥ 35 mg/dL. Dyslipidemia was characterized by the presence of at least one altered lipid parameter.

The collected data were arranged in Excel® spreadsheets and later exported to the SPSS program (for Windows®, version 22.0), in which the statistical analyses were performed. The Kolmogorov-Smirnov normality test was performed for each of the variables. The differences between group means/medians were tested by Mann-Whitney U test or Student's t-test, depending on the normality of variables. To assess the association between anthropometric indicators and school type (independent variables) and dyslipidemia (dependent variable), the odds ratio (OR) was calculated, with a 95% confidence interval (CI). The significance level adopted for the tests was $p < 0.05$.

The project was approved by the Research Ethics Committee of UFPI, under opinion No. 1.495.975, and by the Piauí Secretariat of Education and Culture²⁶. Parents and/or guardians of adolescents authorized their participation in the research by signing the informed consent, and the adolescents confirmed their acceptance by signing the informed consent.

RESULTS

Of the 348 adolescents selected, 21 did not complete all stages of the study because they did not respond completely to the questionnaires or due to blood hemolysis. Thus, the final sample consisted of 327 students, 40.4% male and 59.6% female, and 65.7% were from public schools. The mean age of the students was 16.5 ± 1.2 years. Adolescents with at least one altered lipid parameter accounted for 85.6% of the sample. Dyslipidemia was found in 91.2% of students in public schools and in 75% of students in private schools. The most frequent lipid alteration was hypoalphalipoproteinemia, or low HDL-C (68.8%), followed by total hypercholesterolemia (56.3%). Individuals with high TG and LDL-C accounted for 17.4% and 48%, respectively.

Table 1 shows the mean and median values of the serum lipids evaluated. There was no statistically significant difference in blood lipid levels between genders. On the other hand, there was a significant difference ($p < 0.05$) in relation to the school type for TG, HDL-C and LDL-C, with higher concentrations of TG and lower levels of HDL-C in adolescents in public schools. As for LDL-C, the levels were higher among students in private schools.

The mean BMI in overweight individuals was significantly higher for females with dyslipidemia. There were no differences between subjects with and without dyslipidemia in relation

to WC according to gender (Table 2). For both genders, TC levels were significantly higher and HDL-C levels were lower (both $p < 0.05$) for adolescents with dyslipidemia.

A logistic regression analysis of the lipid profile was performed with anthropometric variables and school type (Table 3). The risk of having altered triglyceride levels was associated with overall excess adiposity (BMI) (OR: 3.32; CI: 1.37-8.04) and excess abdominal fat (WC) (OR: 5.04; CI: 1.24-20.54). On the other hand, overweight, high WC (>90th percentile), and being from public school did not increase the chances of having changes in LDL-C and TC levels. The odds of dyslipidemia were 3.71 times higher in public school students (OR: 3.71; CI: 1.94-7.09). Being from a public school was also associated with increased odds of low HDL-C (OR: 2.81; CI: 1.69-4.66).

DISCUSSION

The high prevalence of dyslipidemia in adolescents is a relevant fact, since changes in serum lipids can cause damage to current and adult health, due to the association with atherosclerosis and, consequently, with cardiovascular disease.

Brazilian studies showed high levels of dyslipidemia in the adolescent population, ranging from 24.2% to 71.4%²⁷⁻³². ERICA verified that the lipid alteration with the highest prevalence in Brazilian adolescents was low HDL-C¹, which was also observed in the present investigation. The high prevalence of lipid disorders in the study population may be due to several factors, such as obesity, unhealthy eating habits, and physical inactivity.

Students who attended public schools had higher TG levels and lower HDL-C levels, while LDL-C levels were also lower. Two Brazilian studies have indicated higher prevalence of dyslipidemia in public schools^{33,27}, similar to the present study. The socioeconomic factors to which public school adolescents are exposed differ from those of students from private institutions and may have caused this higher prevalence of lipid alteration. Income, for example, is a condition that can affect food intake, and thus the lower the income, the higher the prevalence of food and nutrition insecurity, which implies losses in the quality of meals and, consequently, in health status³⁴. Food insecurity is associated with high consumption of foods with a higher energy density, and with a low intake of fruits and vegetables, predisposing the individual to the appearance of cardiometabolic diseases³⁵. Nascimento et al. (2018)³⁶ demonstrated that the low consumption of antioxidant nutrients, many of which are present in foods of plant origin, was associated with lipid alterations in adolescents. Maternal schooling is another factor that relates to the health conditions of adolescents⁷. Therefore, socioeconomic factors that can lead to this situation in public institutions should be better investigated for effective prevention and treatment actions. Furthermore, these findings are relevant and suggest that public school students are at greater risk for cardiovascular disease, but data from private school adolescents are also of concern.

Table 1. Concentrations of serum lipids (mg/dL) in adolescents. Teresina-PI, Brazil, 2016.

	All	Public School	Private School	
	Mean (SD)	Median (P25 – P75)	Mean (SD)	Median (P25 – P75)
n (M/F)	327 (131/195)			
TG				
All	74 (35)	–	77(36)	–
Male	73 (33)	–		
Female	75 (36)	–		
P	0.634*			
HDL-C				
All	–	30 (22- 37)	–	29 (21-35)
Male	–	30 (22- 35)		
Female	–	30 (23-38)		
P	0.219**			
TC				
All	–	159(133- 198)	–	156 (134-202)
Male	–	149 (127-205)		
Female	–	162 (138-196)		
P	0.408**			
LDL-C				
All	–	95 (67- 140)	–	86 (57-132)
Male	–	97 (71-156)		
Female	–	95 (64-130)		
P	0.079**			

SD= standard deviation; P25= 25th percentile; P75= 75th percentile; M/F= male/female; TG= triglycerides; HDL-C= high-density lipoprotein cholesterol; TC= total cholesterol; LDL-C= low-density lipoprotein cholesterol. *P-value derived from Student's t-test. **P-value derived from Mann-Whitney U test.

Table 2. Anthropometric variables and serum lipid levels (mg/dL) in adolescents with or without diagnosis of dyslipidemia, by gender*. Teresina-PI, Brazil, 2016.

	Male Dyslipidemia					Female Dyslipidemia				
	- (n=14)		+ (n=118)		P	- (n=33)		+ (n=162)		P
	Mean (SD)	Median (P25-P75)	Mean (SD)	Median (P25-P75)		Mean (SD)	Median (P25-P75)	Mean (SD)	Median (P25-P75)	
BMI (kg/m2)										
UW/Normal										
weight	20.3 (1.9)	-	20.4 (1.9)	-	0.908*	20.1 (2.1)	-	20.7 (2.4)	-	0,111*
Overweight	26.6 (2.7)	-	28.1 (3.7)	-	0.283*	25.1 (3.3)	-	28,3 (2,7)	-	0,008*
WC (cm)										
< 90th percentile	73.6 (9.8)	-	74.7 (8.3)	-	0.654*	70.1 (8.8)	-	70,6 (7.7)	-	0.769*
> 90th percentile	99 (2.5)	-	107.3 (14.4)	-	0.424*	-	-	94.6 (2.2)	-	†
TC	-	129 (115-141)	-	162 (130-208)	0.001**	-	147 (129-159)	-	172 (141-199)	0.000**
LDL-C	-	70 (56-82)	-	107 (75-160)	0.000**	-	86 (69-101)	-	98 (63-140)	0.105**
HDL-C	-	38 (37-45)	-	29 (21-33)	0.000**	-	41 (37-47)	-	29 (21-36)	0.000**
TG	64 (25)	-	74 (34)	-	0.299**	63 (22)	-	77 (38)	-	0.048*

SD=standard deviation; P25= 25th percentile; P75= 75th percentile; BMI= body mass index; UW= underweight; WC= waist circumference; TC= total cholesterol; LDL-C= low-density lipoprotein cholesterol; HDL-C= high-density lipoprotein cholesterol; TG= triglycerides. †= not applicable. *P-value derived from Student's t-test. **P-value derived from Mann-Whitney U test

Table 3. Anthropometric variables and school type of adolescents in relation to the lipid profile*. Teresina-PI, Brazil, 2016.

Variable		OR (CI)	ADJUSTED HDL-C	P-value
BMI	Underweight/normal weight	1 Reference		0.61
	Overweight	1.18 (0.63-2.18)		
School Type	Private	1 Reference		0.00
	Public	2.81 (1.69-4.66)		
WC	< 90th percentile	1 Reference	LDL-C	0.07
	> 90th percentile	3.04 (0.91-10.14)		
		OR (CI)		P-value
BMI	Underweight/normal weight	1 Reference		0.25
	Overweight	1.41 (0.78-2.54)		
School Type	Private	1 Reference		0.38
	Public	1.24 (0.77-1.99)		
WC	< 90th percentile	1 Reference		0.44
	> 90th percentile	1.58 (0.49-5.03)		
		OR (CI)	Triglycerides	P-value
BMI	Underweight/normal weight	1 Reference		0.00
	Overweight	3.32 (1.37-8.04)		
School Type	Private	1 Reference		0.29
	Public	1.67 (0.64-4.32)		
WC	< 90th percentile	1 Reference		0.02
	> 90th percentile	5.04 (1.24-20.54)		
		OR (CI)	TC	P-value
BMI	Underweight/normal weight	1 Reference		0.44
	Overweight	1.25 (0.70-2.24)		
School Type	Private	1 Reference		0.94
	Public	0.98 (0.52-1.56)		
WC	< 90th percentile	1 Reference		0.67
	> 90th percentile	1.28 (0.40-4.07)		
		OR (CI)	Dyslipidemia	P-value
BMI	Underweight/normal weight	1 Reference		0.50
	Overweight	1.37 (0.55-3.44)		
School Type	Private	1 Reference		0.00
	Public	3.71 (1.94-7.09)		
WC	< 90th percentile	1 Reference		0.79
	> 90th percentile	1.23 (0.26-5.83)		

*Logistic regression analysis considering the effect of an explanatory variable. OR= odds ratio; CI= confidence interval; BMI= body mass index; WC= waist circumference; TC= total cholesterol; LDL-C= low-density lipoprotein cholesterol; HDL-C= high-density lipoprotein cholesterol.

As in other studies^{37,9}, gender did not influence lipid levels. On the other hand, some studies showed higher mean levels of TC, LDL-C, TG and HDL-C in females^{1,38}. The literature shows that in girls a difference in growth and sexual maturation from 14 to 15 years of age can increase lipid levels, including TC³⁸. This study included adolescents older than 15 years, which may explain why this difference

in lipid levels between genders was not observed.

In the present study, obese adolescents with dyslipidemia had a higher BMI as compared to subjects without dyslipidemia. Ghomari-Boukhatem et al. (2015)³⁹ found that higher BMI relates to higher LDL-C levels and lower HDL-C. The mean values of WC did not differ significantly considering adolescents from both genders with and without

dyslipidemia.

In another study³⁷, boys with dyslipidemia had a higher BMI and waist-height ratio, when compared to the group without dyslipidemia. On the other hand, there was no difference between anthropometric variables in female adolescents, unlike the present study.

A recent study showed through regression analysis that there is a relationship between BMI and TC, LDL-C, HDL-C and TG levels³⁰. The literature, in general, points to a strong association between obesity in adolescence and changes in the lipid profile^{38,40,41}. The present study indicated that triglyceride levels are associated with measures of nutritional status, such as high BMI and WC. Obesity can cause inflammatory cascades in the body, which generate different metabolic alterations, such as dyslipidemia and insulin resistance⁴². In addition, changes in the adipose tissue of adolescents, common in obesity, can lead to early sexual maturation, growth abnormalities, hepatic steatosis, and other impairments⁴³. Therefore, obesity should be better prevented and treated in adolescence, because of its relationship with changes in serum lipids and cardiovascular disease and because it compromises quality of life and health in general.

One of the limitations of this study was that we did not address other risk factors for lipid changes, such as food consumption, physical activity, and alcohol consumption. In addition, the fact that we conducted a cross-sectional study requires great caution in the analysis of results, especially regarding causality.

Preventive and more effective measures should be adopted by the health and education sectors in the prevention of dyslipidemia in adolescents, through programs with greater effectiveness. It is necessary to consider that the primary prevention of cardiovascular disease should be started at an early age, and in this sense investments in adolescent health education aimed at combating obesity and other factors associated with dyslipidemia should be greater.

CONCLUSIONS

This study demonstrated a high prevalence of dyslipidemia in adolescents, which can lead to chronic diseases and harmful cardiovascular events in adulthood. Another interesting fact was the higher prevalence of dyslipidemia among adolescents who attended public schools, with higher levels of TG and lower concentrations of HDL-C. With respect to overweight individuals, mean BMI was significantly higher for female adolescents with dyslipidemia.

It has been shown that the risk of hypertriglyceridemia was associated with excess weight (overweight/obesity) and abdominal obesity. Studying at a public school was associated with greater odds of dyslipidemia and low HDL-C.

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