Artículo Original / Original Article

ERICA: Consumption of trans fats and saturated fats associated with dyslipidemia in obese and overweight adolescents

ERICA: Consumo de grasas trans y grasas saturadas asociado a la dislipidemia en adolescentes con sobrepeso y obesidad

ABSTRACT

The study aimed to associate the consumption of trans and saturated fats with dyslipidemia in overweight and obese adolescents who participated in the Study of Cardiovascular Risks in Adolescents (ERICA) from February 2013 to November 2014. Anthropometry, food consumption data, and the lipidogram of 9,538 overweight Brazilian adolescents from macro-regions and Teresina were used in the study. We found an association between saturated fats and HDL-c in Teresina and in the Northeastern macro-region (p -value= 0.002 and p -value= 0.033, respectively), showing that adolescents in Teresina who consumed less than 10% of saturated fats were 2.04-fold more likely to have desirable HDL-c ($OR= 2.04$), while northeastern adolescents were 0.625 less likely to have desirable HDL-c ($OR= 0.625$). In Teresina, there was an association between saturated fat consumption and total cholesterol (p -value= 0.045), showing that adolescents consuming less than 10% of saturated fats had a 0.543-fold lower odds of having desirable total cholesterol levels ($OR= 0.543$). Lipid profile was not associated with consumption of trans fats, but with the consumption of saturated fats. It is important to monitor the lipid profile of adolescents, especially in the presence of overweight. Key-words: Adolescent; Dyslipidemia; Obesity; Overweight; Saturated fatty acids; Trans fatty acids.

RESUMEN

El objetivo fue asociar el consumo de grasas trans y saturadas y dislipidemia en adolescentes con sobrepeso y obesidad que participaron en el Estudio de Riesgos Cardiovasculares en Adolescentes (ERICA), en el período de febrero de 2013 a noviembre de 2014. Se utilizaron datos antropométricos, consumo alimentario y lipidograma de 9.538 adolescentes, residentes en Brasil, macrorregiones y Teresina. En Teresina y Macroregión Nordeste, hubo asociación entre el consumo de grasa saturada y HDL-c (p -valor= 0,002 y p -valor= 0,033), respectivamente, mostrando que, adolescentes teresinenses con consumo menor que 10% la grasa saturada tiene 2,04 veces más probabilidades de tener HDL-c deseables

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($OR= 2,04$); mientras que los nordestinos que consumen menos del 10% de grasa saturada tienen 0,625 veces la probabilidad de tener HDL-c deseables ($OR= 0,625$). En Teresina, hubo asociación entre el consumo de grasa saturada y colesterol total (p -valor= 0,045), mostrando que adolescentes con consumo menor que 10% de grasa saturada tienen 0,543 veces la probabilidad de tener colesterol total deseable ($OR= 0,543$). El perfil lipídico no se asoció al consumo de grasa trans, sino al consumo de grasa saturada. Es importante realizar monitorización del perfil lipídico de adolescentes, especialmente en presencia del sobrepeso.

Palabras clave: Ácidos grasos saturados; Ácidos grasos trans; Adolescente; Dislipidemias; Obesidad; Sobrepeso.

INTRODUCTION

The increase in the prevalence of overweight and obesity in childhood and adolescence has been pointed out as a cause of concern because metabolic alterations and consequences of obesity, evident only in adults in former times, can already be observed in younger age groups^{1,2,3}.

In Brazil, approximately 8.4% of adolescents are affected by obesity, a multifactorial condition associated with morbidities such as dyslipidemia, diabetes, arterial hypertension and other chronic diseases⁴. Among the risk factors for obesity in adolescence are sedentary lifestyle, inadequate diet, genetic factors, and socioeconomic status^{5,6,7}.

Dyslipidemia is caused by changes in lipid metabolism that affect serum lipid and lipoprotein concentrations and can be classified as hyperlipidemia (high levels of LDL-c, triglycerides and total cholesterol) and hypolipidemia (low plasma levels of HDL-c)^{8,9}.

Among complications resulting from changes in plasma lipids, especially in relation to high levels of total cholesterol and LDL-cholesterol, are the progression of atherosclerosis, a higher risk of stroke and coronary diseases, thus contributing to the main causes of morbidity and mortality in Brazil and in the world^{8,10}.

In Brazil, there is a high prevalence of lipid disorders during childhood and adolescence^{11,12}. In Campina Grande, authors identified a prevalence of 85.3% of dyslipidemia in 217 overweight children and adolescents since the pre-school stage. Low HDL-c was the most frequent alteration (80.6%), and its value was significantly lower among the severely obese¹¹.

The Study of Cardiovascular Risks in Adolescents (ERICA) showed a high prevalence of changes in plasma lipids, especially in the North and Northeast regions of Brazil. Research identified low HDL-c (46.8%), high LDL-c (3.5%), hypercholesterolemia (20.1%) and hypertriglyceridemia (7.8%)¹².

Thus, the objective of this study was to investigate the association between consumption of trans and saturated fats and lipid profile of obese and overweight adolescents from the macro-regions of Brazil and, specifically, Teresina the regional capital of Piauí who participated in ERICA.

MATERIAL AND METHODS

This is a complementary project of the Study of Cardiovascular Risks in Adolescents (ERICA), submitted and approved by its Publications Committee. This is a cross-sectional, analytical and descriptive, multicenter, school-based study with a national scope conducted from February 2013 to November 2014.

The total sample of the ERICA was divided into 32 geographic strata and conglomerates of schools and classes, representing the population of school adolescents at the national and regional level, and for the capitals. In the sampling process, 1251 schools were selected in 124 municipalities^{13,14}.

The sample consisted of adolescents between 12 and 17

years of age, enrolled in the last three grades of elementary school (seventh, eighth and ninth grade) or in the first, second or third year of high school, in public and private schools of municipalities with more than 100,000 inhabitants of these five macro-regions of Brazil, who agreed to participate in the study¹⁴.

In the study, adolescents who were outside the age group of 12 to 17 years, pregnant adolescents and those with physical, temporary or permanent disabilities, which did not allow the measurement of anthropometric measures with the instruments used in the research were excluded from the analysis.

It is important to note that ERICA data were grouped into a subset of data according to the degree of integrity of the information collected. Thus, subsets of adolescents were constructed based on the set of information obtained to allow the calculation of sample weights.

The criteria for inclusion and exclusion of study participants eligible for the establishment of the complete sets of information were: Questionnaire: included when all questions included in the 11 thematic blocks of the student questionnaire were answered; Anthropometry: included when at least measures of weight and height were recorded; Blood pressure: excluding measures considered to be invalid (systolic blood pressure equal to or less than diastolic blood pressure); 24-hour food recall: excluding those with an energy consumption of less than 100 kcal.

In this context, of the 102,327 adolescents eligible for the study, 52,300 answered the 24-hour food recall, 52,802 participated in anthropometry and 40,732 participated in blood collection. Thus, 37,023 adolescents presented complete data on anthropometry, 24-hour food recall and blood collection. However, only overweight adolescents with data from these three stages were considered for this study (n= 9,538).

Data were collected by a team of evaluators previously trained using standardized techniques. The dietary investigation consisted of an interview about diet in the previous 24 hours. Two 24-hour recalls were performed: the first was performed with all adolescents and the second with a subsample of six adolescents per school¹³.

In order to analyze the adequacy of consumption of saturated and trans fats, cut-off points were used as recommended by the World Health Organization, which establishes tolerable limits of trans fat intake of up to 1% of daily energy consumption, and of saturated fats up to 10%¹⁵.

Nutritional status was established by the calculation of the Body Mass Index (BMI= weight/height²) and its classification by the World Health Organization BMI curves specific for age and sex, by z-score.

Collection of blood samples was the responsibility of clinical analysis laboratories. All participants were instructed to abstain from food for at least 10-12 hours prior to collection of blood samples. Total Cholesterol (TC) and Triglycerides (TG) were analyzed by Enzymatic Kinetics; High Density Lipoproteins (HDL-c), by Enzymatic Colorimetric Assay;

and Low Density Lipoproteins (LDL-c) was calculated by the Friedewald equation¹⁶.

For lipid profile classification, the presence of dyslipidemia was defined by elevated levels of TC, LDL-c or TG, or low levels of HDL-c, according to the reference values of the Brazilian Directive on Dyslipidemias and Atherosclerosis Prevention - 2017⁹, which determines the following desirable cut-off points for adolescents: TC < 170mg/dL; LDL-c < 110mg/dL, TG < 90mg/dL; and HDL-c > 45 mg/dL.

Statistical analysis was done in the Nucleus of Statistical Support to Research (NAEP), using the database of the ERICA Publications Committee, and the Stata 15 software, version 14. Tables with crossing data on trans and saturated fat consumption and levels of plasma lipids were generated for adolescents living in Brazil, in the macro-regions, and in the capital Teresina-PI, where simple frequencies (n) and relative frequencies (%) were presented.

Due to the complex sampling design of the ERICA, the Rao-Scott chi-square test, an adjusted version of Pearson's chi-square test, was used. For the variables that obtained significance in the test, a logistic regression was performed to investigate the odds ratio (OR), considering the same design. The level of significance was 5%.

The ERICA was approved by the Research Ethics Committees of the Institute of Collective Health Studies of the Federal University of Rio de Janeiro (Report nº 01/2009, Process 45/2008) and from the institutions responsible for conducting the study in each Brazilian state and in the Federal District.

All the participants interviewed and examined signed written authorization and parents provided signed informed consent¹³.

RESULTS

Data on saturated and/or trans fat intake and lipid profile (LDL-c, HDL-c, Triglycerides and Total Cholesterol)

were analyzed from 9,538 overweight Brazilian adolescents participating in the ERICA.

No association was observed between fat intake (saturated or trans) and lipid profile among Brazilian adolescents. However, there was evidence of an association between HDL-c level and the consumption of saturated fats (p-value= 0.082) (Table 1).

When analyzing the data per region, it was observed that there was an association between saturated fat intake and HDL-c level (p-value= 0.002) among overweight adolescents residing in the Northeast region. Northeastern adolescents consuming less than 10% of saturated fat presented a 0.625 odds of having desirable HDL-c levels when compared to adolescents consuming more than 10% of this type of fat (OR= 0.625, 95% CI= 0.463 - 0.845) (Table 2).

For the other macro-regions of Brazil (Central-West, North, Southeast, and South), there was no association between fat consumption (saturated or trans) and lipid profile.

In the capital Teresina, the Rao-Scott chi-square test indicated an association between consumption of saturated fat and HDL-c level (p-value= 0.033) for overweight or obese adolescents (Table 3).

In this association, the odds ratio OR= 2.04 (95% CI= 1.06-3.94) was obtained, implying that adolescents consuming less than 10% of total calories from saturated fats had 2.04-fold higher odds of having desirable HDL-c levels when compared to adolescents who consumed more than 10% of saturated fats.

Among adolescents of Teresina, an association between saturated fat consumption and total cholesterol level was observed (p-value= 0.045). Adolescents who consumed less than 10% of total calories from saturated fats have 0.543-fold lower odds of having desirable total cholesterol when compared to adolescents who consume more than 10% of saturated fats (OR= 0.543, 95% CI= 0.277-0.990). This finding can be confirmed by observing the absolute and relative frequencies (Table 3).

Table 1. Association between saturated and trans fat intake and plasma lipid levels in overweight Brazilian adolescents (n= 9,538). ERICA, 2013-2014.

	LDL-c			HDL-c			TG			TC		
	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p
TRANS FATS												
<1% of total calories	4857 (80,1)	1260 (19,9)	0,107	2559 (39,2)	3565 (60,8)	0,533	3630 (61,1)	2493 (38,9)	0,653	4450 (73,5)	1674 (26,5)	0,662
>1% of total calories	2721 (83,1)	700 (16,9)		1404 (41,0)	2019 (59,0)		2055 (62,2)	1367 (37,8)		2484 (74,6)	939 (25,4)	
SATURATED FATS												
<10% of total calories	3595 (81,2)	887 (18,8)	0,993	1819 (37,5)	2668 (62,5)	0,082	2618 (61,7)	1868 (38,3)	0,878	3293 (74,8)	1194 (25,2)	0,546
>10% of total calories	3983 (81,2)	1073 (18,8)		2144 (41,7)	2916 (58,3)		3067 (61,4)	1992 (38,6)		3641 (73,2)	1419 (26,8)	

D: Desirable, ND: Not desirable, LDL-c: Low-Density Lipoprotein cholesterol, HDL-c: High-Density Lipoprotein cholesterol, TG: Triglycerides, TC: Total Cholesterol, Rao-Scott chi-square test: p<0,05,

Table 2. Association between saturated and trans fat intake and plasma lipid levels in overweight adolescents living in the Northeast region of Brazil (n= 2,864), ERICA, 2013-2014.

	LDL-c			HDL-c			TG			TC		
	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p
TRANS FATS												
<1% of total calories	1498 (82,4)	398 (17,6)	0,31	729 (35)	1169 (65)	0,878	3630 (61,1)	2493 (38,9)	0,653	4450 (73,5)	1674 (26,5)	0,662
>1% of total calories	759 (84,5)	209 (15,5)		369 (35,6)	599 (64,4)		2055 (62,2)	1367 (37,8)		2484 (74,6)	939 (25,4)	
SATURATED FATS												
<10% of total calories	1050 (85,3)	252 (14,7)	0,13	477 (29,5)	825 (70,5)	0,002*	737 (56,1)	565 (43,9)	0,903	972 (78,6)	438 (21,4)	0,154
>10% of total calories	1207 (81,1)	355 (18,9)		621 (40,1)	943 (59,9)		940 (55,5)	624 (44,5)		1126 (74,2)	768 (25,8)	

D: Desirable, ND: Not desirable, LDL-c: Low-Density Lipoprotein cholesterol, HDL-c: High-Density Lipoprotein cholesterol, TG: Triglycerides, TC: Total Cholesterol, Rao-Scott chi-square test: p<0,05,

Table 3. Association between saturated and trans fat intake and plasma lipid levels in overweight adolescents living in the capital Teresina, PI, (n= 203), ERICA, 2013-2014.

	LDL-c			HDL-c			TG			TC		
	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p	D N (%)	ND N (%)	p
TRANS FATS												
<1% of total calories	96 (81,8)	20 (18,2)	0,922	38 (31,5)	78 (68,5)	0,338	73 (56,5)	43 (43,5)	0,322	87 (73,9)	29 (26,1)	0,675
>1% of total calories	66 (82,6)	(17,4)		22 (23,8)	65 (76,2)		52 (46,3)	35 (53,7)		64 (77,3)	23 (22,7)	
SATURATED FATS												
<10% of total calories	63 (79,3)	17 (20,7)	0,461	27 (36,7)	53 (63,3)	0,033*	46 (50,9)	34 (49,1)	0,920	53 (68,5)	27 (31,5)	0,045*
>10% of total calories	99 (83,9)	24 (16,1)		33 (22,1)	90 (77,9)		79 (52,1)	44 (48)		98 (80)	25 (20,0)	

D: Desirable, ND: Not desirable, LDL-c: Low-Density Lipoprotein cholesterol, HDL-c: High-Density Lipoprotein cholesterol, TG: Triglycerides, TC: Total Cholesterol, Rao-Scott chi-square test: p<0,05,

DISCUSSION

Components from the diet, especially fats, have a relevant role in the repercussion of the lipid profile, including the HDL-c fraction¹⁷. Studies have shown that the consumption of foods low in trans fatty acids and saturated fats promotes beneficial effects on serum cholesterol concentrations^{18,19}. In contrast, consumption of trans fats has been related to increased LDL-c, reduced HDL-c, increased systemic inflammation, oxidative stress, insulin resistance, and impairment of endothelial function²⁰.

The World Health Organization recommends maximum trans fat consumption up to 1% of the total daily energy value¹⁵. In Brazil, a representative study showed that the average trans fat intake by adolescents is within WHO recommendations. Specifically, in the North and South, the consumption exceeds this percentage, reaching 1.1% and 1.3% of the total daily caloric value, respectively²¹.

Despite the high trans fat intake among adolescents in these regions, the present study showed no association between such consumption and plasma lipids. However, it is known that the effect of trans fat intake on HDL-c, VLDL-c, TG and other fractions may depend on several factors, such as the ingestion of polyunsaturated fatty acids²².

In relation to saturated fat intake, the average consumption by adolescents in Brazil and in the Northeast region is similar (11.5% of the total daily caloric intake among girls aged 14 to 17 years and 10.8% among boys in the same range age)²¹. This is a cause for concern because the WHO recommendation is up to 10% of daily calories¹⁵.

Individuals who consume large amounts of fats, especially saturated fats, have higher serum cholesterol levels than those who consume smaller amounts, and this relation is directly proportional^{19,23}. However, this study showed an inverse association between saturated fat intake and total

cholesterol among adolescents in the capital Teresina.

In relation to HDL-c, the consumption of saturated fatty acids may be related to the increase of this lipoprotein, and this effect is more pronounced in medium-chain saturated fatty acids compared to long chain saturated fatty acids²⁴, since the effects of HDL-c are increased as the length of the chain is reduced²⁵. A meta-analysis has confirmed the increase of HDL-c by the consumption of saturated fatty acids²⁶.

Thus, the results found in the present study in relation to the Northeast region confirm the findings of the literature. However, when analyzing the data for Teresina, an inverse association between the two variables was found.

Several factors may explain our results, including those that influence the metabolism of HDL-c, such as: obesity, type 2 diabetes, inflammation, smoking, hormonal action, and physical exercise^{27,28}. In addition, it is worth noting the influence of high consumption of carbohydrates, polyunsaturated and monounsaturated fats^{17,29,30}. The lack of investigation of the mentioned variables and the complexity of the sampling design of the ERICA represent limitations of the present study.

It is known that the degree of obesity plays an important role in the appearance of metabolic alterations^{31,32}, and that obese adolescents are more likely to have a reduction in the HDL-c fraction, dysregulation of endothelial function, and also more atherogenic lipoproteins^{33,34}.

Furthermore, characterized as a chronic inflammatory process of low intensity, obesity is responsible for triggering the activation of the signaling pathway of the Toll-4 receptor, one of the main triggers of the inflammatory response induced by obesity. This pathway responds to increased exposure to saturated fatty acids³⁵.

This metabolic inflammation prevents insulin signaling and reverse cholesterol transport, reflecting in the reduction of metabolic control and a higher risk for development of dyslipidemia and cardiovascular diseases^{36,37}.

Evidence suggests that saturated fats may have little effect on LDL-c in obese people³⁰. A randomized clinical trial with 322 obese subjects demonstrated that a diet rich in saturated fats and low in carbohydrates compared to others was considered the most effective because it increased the HDL/LDL ratio. In this trial, there was an increase in HDL-c during weight loss in all groups³⁸.

The results of the present study showed that the cardiovascular risk factor related to dyslipidemia was not related to the consumption of trans fats, but rather of saturated fats by overweight adolescents from the Northeast region of the country and from the capital Teresina. This finding may be due to the differences between stages of the epidemiological and nutritional transitions of the different regions and the different eating habits across Brazil.

Stratification by macro-regions is important considering different lifestyles and eating habits. There is evidence that stratifying by macro-regions can illustrate important differences in the prevalence of consumption of some

foods and nutrients²¹.

A cross-national study investigating the pattern of food consumption among Brazilian adolescents, showed a higher prevalence of healthy food patterns in the Southeast (31.5%), South (33.9%) and Central-West regions (34.5%). On the other hand, the North and Northeast regions presented lower proportions for this food pattern (20.6 and 18.6%, respectively)³⁹.

Thus, different patterns of food consumption in these regions, in addition to portraying the usual consumption of food and nutrients, may reflect differentiation in the emergence of chronic diseases and health status of the study population. In this sense, the ERICA results point to important regional contrasts, which need to be better explored in the planning of effective public health interventions and to redirect food and nutrition policies.

It is important to point out that there is no isolated ingestion of saturated or trans fats in the diet. Thus, both the HDL-c profile and the other blood lipid fractions in this population are also the result of the interaction between the other macronutrients and micronutrients resulting from the food matrix. Other non-dietary factors, such as nutritional status, lifestyle, genetic profile, and the complexity of the sample of the ERICA should be considered.

CONCLUSIONS

The imbalance in the consumption of macronutrients, specifically excessive consumption of fats, can cause damage to metabolic processes and changes in lipid profile. In this study, consumption of saturated fat was associated with HDL-c level among overweight adolescents living in the Northeast region of Brazil and in the capital Teresina.

In addition, the importance of moderate consumption of trans fatty acids and saturated fat from early childhood is emphasized, taking into account that these habits may affect cardiovascular health and increase obesity in adult life. Furthermore, the high prevalence of dyslipidemia among adolescents reinforces the need to monitor lipid profile, especially in the presence of excess weight.

Other studies should be conducted on the subject in order to elucidate the gaps related to the role of dietary fats in the blood lipid profile in this population because the results on their consumption remain inconsistent and complex, as levels involve several genetic, dietary and of lifestyle factors.

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