DOI: 10.1590/1980-5497201500040020

ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Fatty acid intake and metabolic syndrome among overweight and obese women

Ingestão de ácidos graxos e síndrome metabólica entre mulheres com sobrepeso e obesidade

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ABSTRACT: ***Objective:*** To examine relations between fatty acids intake and metabolic syndrome (MetS) status among overweight and obese women (n = 223). ***Methods:*** This was a cross-sectional study. The physical and laboratory tests included anthropometry, body composition evaluation and measurements of blood pressure, fasting blood glucose, insulinemia and lipid profiles. A three-day food diary was used to evaluate fatty acids consumption. Statistical analysis included χ^2 test and *odds ratio* measurements. ***Results:*** The women had 35.2 (6.9) years old and 15.2% presented MetS. Women with MetS presented higher serum levels of very low-density lipoprotein cholesterol, triglycerides, glucose and insulin in addition to higher diastolic blood pressure in comparison to women without MetS. Overweight women with MetS consumed higher amounts of monounsaturated fatty acids — 24.3 g (24.7 – 36.4) *versus* overweight women without MetS — 23.9 g (23.8 – 26.8), polyunsaturated fatty acids — 16.7 g (14.6 – 21.1) *versus* overweight women without MetS — 13.6 g (13.8 – 15.8) and linoleic fatty acids — 15.9 g (6.5) *versus* overweight women without MetS — 13.1 g (5.1). Among obese women with MetS, higher intake of linoleic fatty acids was also noted — 17.6 g (6.1) *versus* obese women without MetS — 14.3 g (6.6) in addition to higher consumption of trans fatty acids — 4.7 g (4.8 – 6.3) *versus* obese women without MetS — 3.9 g (2.9 – 4.6). Increased quartiles of monounsaturated, polyunsaturated, linoleic and trans fatty acid intake were significantly associated with a greater occurrence of MetS. ***Conclusion:*** Lipid intake may be related to MetS, although other factors also need to be considered, such as lifestyle, genetics and metabolism.

Keywords: Obesity. Food consumption. Fats. Lipids. Nutrients. Metabolic Syndrome X.

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Conflict of interests: nothing to declare – **Financial support:** none.

RESUMO: ***Objetivo:*** Examinar as associações existentes entre ingestão de ácidos graxos e a síndrome metabólica (SM) entre mulheres com sobrepeso e obesidade (n = 223). ***Métodos:*** Trata-se de estudo transversal. Os testes físicos e laboratoriais incluíram antropometria, avaliação da composição corporal e mensuração da pressão arterial, glicemia de jejum, insulinemia e perfil lipídico. Registros alimentares de três dias foram utilizados para avaliação do aporte de ácidos graxos na dieta. Análises estatísticas contemplaram teste do χ^2 e estimação de *odds ratio*. ***Resultados:*** As mulheres apresentavam 35,2 (6,9) anos de idade e a prevalência de SM foi de 15,2%. Mulheres com SM apresentaram níveis séricos mais elevados de VLDL-c (*very low-density lipoprotein cholesterol*), triglicérides, glicose e insulina, além de maior medida de pressão arterial diastólica em relação às não portadoras da síndrome. Mulheres com sobrepeso e SM apresentaram maior consumo de ácido graxo monoinsaturado — 24,3 g (24,7 – 36,4) *versus* mulheres com sobrepeso sem SM — 23,9 g (23,8 – 26,8), poli-insaturado — 16,7 g (14,6 – 21,1) *versus* mulheres com sobrepeso sem SM — 13,6 g (13,8 – 15,8) e linoleico — 15,9 g (6,5) *versus* mulheres com sobrepeso sem SM — 13,1 g (5,1). Nas obesas, as mulheres com SM também apresentaram maior ingestão de ácido graxo linoleico — 17,6 g (6,1) *versus* mulheres obesas sem SM — 14,3 g (6,6), além de maior consumo de gorduras *trans* — 4,7 g (4,8 – 6,3) *versus* mulheres obesas sem SM — 3,9 g (2,9 – 4,6). Quartis mais elevados da ingestão de ácidos graxos monoinsaturados, poli-insaturados, linoleico e *trans* foram significativamente associados a grande ocorrência de SM. ***Conclusão:*** A ingestão de lipídeos parece se associar à ocorrência de SM, embora outros fatores também devam ser considerados, tais como estilo de vida, genética e metabolismo.

Palavras-chave: Síndrome X Metabólica. Obesidade. Consumo de alimentos. Gorduras. Lipídeos. Nutrientes.

INTRODUCTION

Metabolic syndrome (MetS) involves a combination of clinically specific risk factors including insulin resistance, dyslipidemia, high blood pressure and obesity[1]. The prevalence of MetS is rapidly increasing worldwide, which is largely a consequence of the ongoing obesity epidemic[2].

The available evidence indicates that, in most countries, between 20 and 30% of the adult population can be characterized as having MetS. In parts of the developing world, in which young adults predominate in the population, the prevalence of MetS is lower; but with increasing affluence and an aging population, the prevalence will undoubtedly rise[3]. In Latin America, the general prevalence of MetS is estimated at 24.9% and it is found more frequently in women than in men (25.3 *versus* 23.2%)[4]. In Brazil, a systematic review with ten cross-sectional studies identified a general prevalence of MetS of 20.6% (range: 14.9 – 65.3%)[5].

Diet and physical activity are the first choice for treating MetS, but little is known about what methods are effective. An energy-prudent diet coupled with moderate levels of physical activity favorably affects several components of MetS. However, the effects of macro and micronutrients in the treatment of MetS are still mostly unknown[6].

In this context, it is crucial to understand the link between dietary patterns and the occurrence of MetS, with the aim of proposing new strategies of intervention. There are a lot of controversial findings in the literature about how fatty acids intake affects the development of MetS[7]. The World Health Organization (WHO) published in 2011 dietary recommendations on fatty acids, aiming at the prevention of chronic diseases, such as MetS. In accordance to this organization, saturated fatty acids (SFA) should represent 10% of dietary energy and its excess contributes to raise LDL and total cholesterol/HDL cholesterol ratio in comparison to monounsaturated (MUFA) or polyunsaturated (PUFA) fatty acids. These two types of fat should represent 15 – 20% and 6 – 11% of dietary energy, respectively. Linoleic fatty acids participation in the diet should be of 2.5 – 9.0% and the impact of its consumption is the lower risk of fatal coronary heart disease (CHD) events[8].

The present study aimed to examine the possible relation between fatty acids intake and MetS status among overweight and obese Brazilian women.

METHODS

This was a cross-sectional study conducted among overweight and obese female residents in São Paulo, Brazil, which was approved by the Research Ethics Committee of the Federal University of São Paulo (UNIFESP) (No. 0972/06). This study made use of data from 223 overweight and obese women who were selected through announcements in printed media (small-circulation newspapers), outpatient clinics and public places, which invited women to enroll in a weight reduction program.

To select these women, the following inclusion criteria were adopted: aged between 25 and 48 years and with a body mass index (BMI) between 25 and 39.9 kg/m^2. The following were taken to be exclusion criteria: presence of chronic diseases other than obesity (renal diseases, diabetes, hypertension, hyper or hypothyroidism or hepatic diseases) that were found at the clinical assessment or were self-reported; frequent use of medications (antidiabetics, anticonvulsants or corticosteroids); intense practice of physical activity; and pregnancy or lactation. These medications and these conditions were excluded because they can influence body weight and fat consumption. In addition, women that were receiving nutritional counseling were also excluded.

After agreeing to participate in the study, which was formalized through signing an informed consent, the participants were interviewed by trained investigators using standardized questionnaires constructed specifically for this study. Women were asked for their age, food intake, blood pressure, anthropometric and biochemical data.

The food intake evaluation consisted of the assessment of energy and lipid fractions intake. Three-day food diaries were used in accordance with suggestions by the Institute of Medicine[9]. After the respondents completed the food diaries, a face-to-face interview was conducted to clarify portion size and verify completeness. Women were also asked about the ingredients used in cooking, which are known to be fat sources. A photographic food atlas was used to quantify portion size and the respondents were also asked to keep food packaging. Homemade recipes and measurements were standardized according to Brazilian composition tables. The data obtained were analyzed with the aid of the Nutrition Data System for Research (NDSR) software (University of Minnesota, 2005).

Blood pressure was measured twice by physicians, at the beginning and at the end of the interview, in accordance with the recommendations of the Sixth Brazilian Guidelines for Arterial Hypertension[10]. In the present analysis, we used the mean value of these two measurements.

The anthropometric evaluation was performed by a nutritionist. The women's weight and height were measured in accordance with the techniques recommended by the World Health Organization[11]. Weight and height data were used to calculate the BMI, which was defined as the weight in kilograms divided by the square of the height. The BMI was classified in accordance with the criteria proposed by the WHO[11]. The waist circumference was assessed in accordance with the recommendations from WHO[12], taking a cutoff point of ≥ 80 cm, as proposed by the International Diabetes Federation (IDF)[13]. Body composition was also assessed using dual-energy X-ray absorptiometry (DXA), HOLOGIC QDR 4500A (Hologic Inc., Wal-tham, MA, USA).

Furthermore, a venous blood sample was obtained after a 12-hour fast to measure triglycerides, total cholesterol, low-density lipoprotein cholesterol (LDL-c), very low-density lipoprotein cholesterol (VLDL-c), high-density lipoprotein cholesterol (HDL-c), plasma glucose and insulin. Blood lipids and triglycerides were measured by enzymatic colorimetric methods; LDL-c and VLDL-c were calculated by the Friedlander equation; serum glucose concentrations were determined using a spectrophotometer UV-1601PC (Shimadzu Corp., Kyoto, Japan) and serum insulin levels were determined with a radioimmunoassay kit (Molecular Research Center, Inc., Cincinnati, USA).

The homeostasis assessment model of insulin resistance (HOMA-IR) was also assessed by multiplying fasting plasma glucose (mmol) by fasting serum insulin (uU/mL) and dividing the result by 22.5[14].

The presence of MetS was investigated for all women, using the IDF classification[13], which has a cutoff of abdominal circumference ≥ 80 cm. In addition, two of the following had to be present: triglycerides ≥ 150 mg/dL or under treatment; blood pressure ≥ 130/85 mmHg or under treatment; HDL-c < 50 mg/dL or under treatment; fasting blood glucose ≥ 100 mg/dL, or glucose intolerance or diabetes[13].

The statistical analyses were performed with the Statistical Package for the Social Sciences software (SPSS), version 12. The Kolmogorov-Smirnov normality test was performed. Student's t-test and one-way ANOVA were used to compare means between overweight and obese women. Mann-Whitney and Kruskal-Wallis tests were used to compare medians between these groups. The χ^2 and Fisher's exact test were used to compare proportions. Analyses were made comparing obese and overweight women aiming to know if there were differences in the relation between MetS and fatty acids consumption in accordance to the body weight level.

The nutrients were adjusted for energy content by means of the residual nutrient method proposed by Willett WC and Stampfer[15]. This adjustment was done for all fatty acids because of the known relationship between macronutrients and energy[15]. The significance level used was 5%, *i.e.* $p < 0.05$. The *odds ratio* (OR) was calculated with the Epi Info software, version 6.0. The variables with normal distributions were presented in the form of means and standard deviations, and other variables were presented in the form of medians with 95% confidence intervals (95%CI).

RESULTS

This study included 152 overweight women and 71 obese women with a mean age of 35.2 (6.9) years. All of these women presented body fat percentages greater than the recommendations for their age group. In addition, 15.2% of this population presented MetS, which was 14.5% among the overweight women and 16.9% among the obese women ($p = 0.638$). The clinical and biochemical parameters and HOMA-IR were less favorable among the women presenting with MetS (Table 1).

The energy and fatty acids intake according to nutritional status and presence of MetS are presented in Table 2. After energy intake adjustment, the overweight women that presented MetS had a significantly greater mean/median intake in grams of saturated [26.6 g *versus* overweight women without MetS: 20.8 g, $p < 0.05$], monounsaturated [24.3 g *versus* overweight women without MetS: 23.9 g, $p < 0.05$], polyunsaturated [16.7 g *versus* overweight women without MetS: 13.6 g, $p < 0.05$] and linoleic fatty acids [7.2% *versus* overweight women without MetS: 6.2%, $p < 0.05$] than did those without MetS (Table 2; Graph 1). In the group of obese women, those with MetS had a significantly greater mean/median intake in grams of linoleic [17.6 g *versus* obese women without MetS: 14.3 g, $p < 0.05$] and trans fatty acids [4.7 g *versus* obese women without MetS: 3.9 g, $p < 0.05$] (Table 2; Graph 2).

An association between fatty acid intake and occurrence of MetS was found, such that increases in monounsaturated, polyunsaturated, linoleic and trans fatty acid intake were significantly associated with a greater OR among overweight and obese women (Table 3).

DISCUSSION

Results showed a high prevalence of MetS in the sample. Greater intake of monounsaturated, polyunsaturated, linoleic and trans fatty acids was associated with the occurrence of this disease among women. However, no relation between MetS and linolenic acid intake was observed.

Comparisons between the MetS prevalence data found in this study and the data found in other studies are limited by differences in methodological characteristics, ethnicity and diagnostic criteria for MetS[1]. In the present study, we focused on comparing prevalence data among studies that adopted the IDF criteria for MetS diagnosis.

Concerning worldwide studies that evaluated the prevalence of MetS using IDF definition, rates included 30.3% in 5,105 Norwegian women with a mean BMI of 30.2 kg/m² (4.5 kg/m²)[16], 25.8% in 26,001 Indian individuals with a mean BMI of 25.7 kg/m² (3.1 kg/m²)[17], and 22.5% in 14,425 individuals in Nepal (28% were overweight and 32% were obese)[18].

Table 1. Body composition, biochemical profile and blood pressure of overweight and obese women by presence or absence of metabolic syndrome.

Characteristics	Overweight women		Obese women	
	Presence of MetS	Absence of MetS	Presence of MetS	Absence of MetS
n (%)	22 (14.5)	130 (85.5)	12 (16.9)	59 (83.1)
Age (years)	35.3 (6.1)	34.7 (7.1)	41.0 (6.2)	34 (6.4)*
Waist circumference (cm)	96.8 (4.4)	93.8 (5.8)	106.7 (6.6)	104.4 (5.9)
Total body fat (%)	38.9 (3.3)	39.7 (3.6)	43.7 (3.0)	44.7 (3.7)
Trunk fat (%)	39.4 (2.9)	39.9 (3.3)	42.1 (2.7)	42.6 (3.0)
Total cholesterol (mg/dL)	204.7 (30.9)	191.7 (32.2)	210.3 (53.4)	190.5 (29.6)
LDL-c (mg/dL)	120.3 (27.9)	109.4 (27.8)	128.8 (44.8)	113.46 (25.7)
HDL-c (mg/dL)[#]	47.0 (45.4 – 55.1)	61.0 (61.2 – 65.8)**	44.5 (40.3 – 52.7)	55.0 (55.5 – 61.0)**
VLDL-c (mg/dL)[#]	35.5 (29.0 – 39.5)	17.0 (17.3 – 20.1)**	33.5 (31.0 – 40.0)	18.0 (17.1 – 20.5)**
Triglycerides (mg/dL)[#]	178.0 (145.1 – 197.6)	86.0 (86.7 – 100.4)**	167.5 (155.4 – 194.3)	90.0 (85.7 – 102.3)**
Glucose (mg/dL)[#]	95.0 (93.2 – 102.7)	88.0 (88.2 – 90.4)**	94.5 (90.2 – 103.5)	91.0 (89.8 – 93.2)**
Insulin (mg/dL)[#]	14.6 (11 – 16.3)	8.5 (8.8 – 10.3)**	13.1 (9.7 – 18.2)	11.8 (10.6 – 13.5)**
HOMA-IR	3.3 (1.4)	2.1 (1.0)**	3.4 (1.7)	2.7 (1.3)
Systolic BP (mmHg)	119.7 (16.9)	111.1 (9.3)**	121.8 (17.0)	114.9 (9.2)
Diastolic BP (mmHg)	82.8 (9.9)	76.1 (7.5)**	89 (13.5)	79.4 (6.9)**

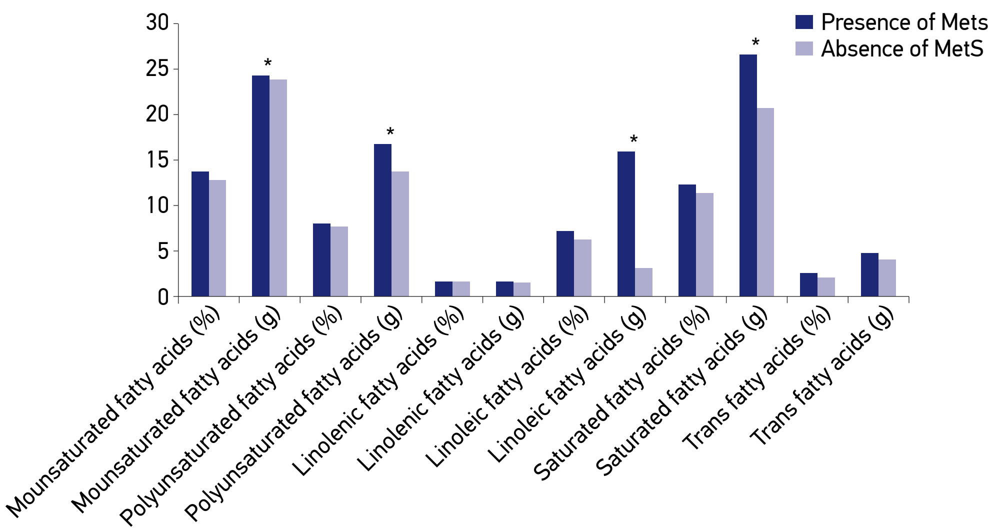
*p < 0.05; **p < 0.01; [#]Variables without a normal distribution.
The Student's *t*-test was used for variables with normal distribution and the Mann-Whitney test, for variables without normal distribution. Comparisons were made within each nutritional status category.
MetS: metabolic syndrome; LDL-c: low-density lipoprotein cholesterol; HDL-c: high-density lipoprotein cholesterol; VLDL-c: very low-density lipoprotein cholesterol; HOMA-IR: homeostasis assessment model of insulin resistance; BP: blood pressure.

In Brazil, Silveira *et al.*[19] conducted a survey with 3,599 subjects of the 1982 Pelotas Birth Cohort. Most of the sample (65.2%) was composed of healthy individuals (BMI = 18.5 to 24.9 kg/m²), and the prevalence of MetS was 6.7%, which is lower than the rate observed in the present study. These findings can be explained by differences between the samples in relation to nutritional status, sex and age. Regarding the age variable, all the subjects studied

Table 2. Dietary intake among overweight and obese women by presence or absence of metabolic syndrome.

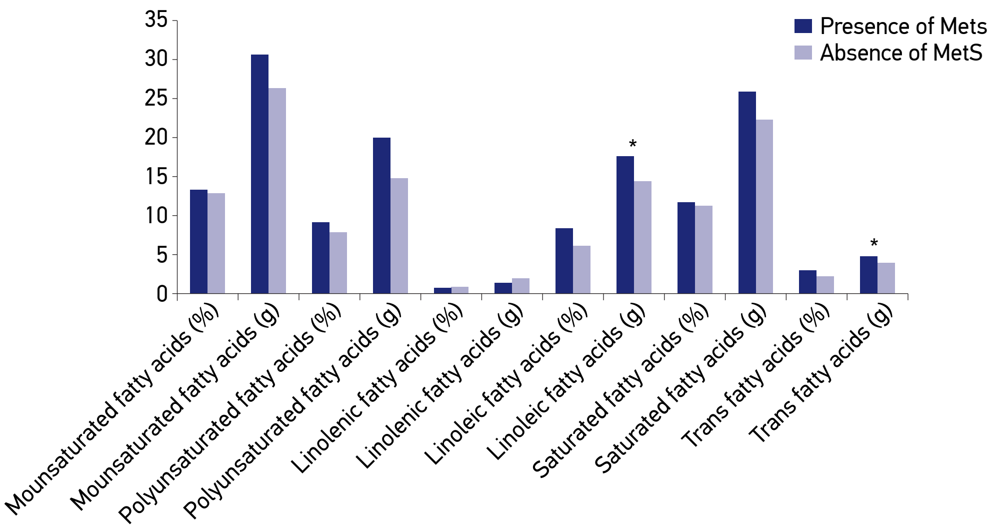
Variable	Overweight women		Obese women	
	Presence of MetS	Absence of MetS	Presence of MetS	Absence of MetS
Energy (kcal)	1,745.2 (46.1)	1,780.6 (525.2)	1,893.8 (462.5)	1,756.5 (453.6)
Monounsaturated fatty acids (%)	13.7 (12.7 – 14.6)	12.8 (12.6 – 13.6)	13.2 (11.8 – 15.2)	12.8 (12.5 – 15.6)
Monounsaturated fatty acids (g)	24.3 (24.7 – 36.4)	23.9 (23.8 – 26.8)*	30.5 (23 – 37)	26.2 (24.3 – 34.7)
Polyunsaturated fatty acids (%)	7.9 (1.9)	7.7 (1.8)	9.1 (2.1)	7.8 (2.6)
Polyunsaturated fatty acids (g)	16.7 (14.6 – 21.1)	13.6 (13.8 – 15.8)*	19.9 (15.7 – 24.1)	14.8 (14.3 – 18.3)
Linolenic fatty acids (%)#	1.6 (1.5 – 1.7)	1.5 (1.4 – 1.9)	0.7 (0.6 – 0.8)	0.8 (0.8 – 0.9)
Linolenic fatty acids (g)	1.67 (0.6)	1.6 (0.7)	1.4 (0.5)	1.9 (1.1)
Linoleic fatty acids (%)#	7.2 (3.4 – 10.8)	6.2 (6.5 – 7.7)*	8.4 (6.7 – 12.3)	6.2 (6.1 – 8.1)*
Linoleic fatty acids (g)	15.9 (6.5)	13.1 (5.1)*	17.6 (6.1)	14.3 (6.6)*
Saturated fatty acids (%)#	12.3 (11.7 – 14)	11.4 (11.1 – 11.9)	11.6 (10.4 – 12.4)	11.2 (10.8 – 13.5)
Saturated fatty acids (g)#	26.6 (23.3 – 33.7)	20.8 (21.9 – 23.3)*	25.8 (19.9 – 30)	22.3 (20.7 – 29.9)
Trans fatty acids (%)#	2.5 (2.3 – 2.9)	2.2 (1.6 – 2.4)	2.9 (2.3 – 2.9)	2.2 (1.6 – 2.4)
Trans fatty acids (g)#	4.80 (4.8 – 5.7)	4.1 (3.1 – 6.2)	4.7 (4.8 – 6.3)	3.9 (2.9 – 4.6)*

*$p < 0.05$; #Variables without a normal distribution.
The Student's *t*-test was used for variables with normal distribution and the Mann-Whitney test, for variables without normal distribution. Comparisons were made within each nutritional status category.
MetS: metabolic syndrome.



*p < 0.01. The Student's *t*-test was used for variables with normal distribution and the Mann-Whitney test, for variables without normal distribution.
MetS: metabolic syndrome.

Graph 1. Mean or median of fatty acids intake among overweight women by presence or absence of metabolic syndrome.



*p < 0.01. The Student's *t*-test was used for variables with normal distribution and the Mann-Whitney test, for variables without normal distribution.
MetS: metabolic syndrome.

Graph 2. Mean or median of fatty acids intake among obese women by presence or absence of metabolic syndrome.

Table 3. Occurrence of metabolic syndrome by quartiles of fatty acid intake adjusted for energy in the diet of overweight and obese women.

	Quartiles of intake				
	1 - lowest (n = 55)	2 (n = 56)	3 (n = 56)	4 - highest (n = 56)	p-value
Monounsaturated fatty acids (g)	16.9 (15.6 – 17.1)	22.3 (22.0 – 22.6)	27.9 (27.4 – 28.5)	38.4 (37.2 – 46.8)	0.027
Presence of MetS (n)	5	9	5	15	
OR (95%CI)	–	1.1 (0.5 – 2.2)	0.5 (0.2 – 1.3)	2.4 (1.3 – 4.3)	
Polyunsaturated fatty acids (g)	9.4 (8.5 – 9.3)	13 (12.5 – 13.1)	16.2 (16.2 – 17.5)	22.5 (23.3 – 26.2)	0.019
Presence of MetS (n)	3	6	11	14	
OR (95%CI)	–	0.6 (0.3 – 1.5)	1.4 (0.7 – 2.7)	2.1 (1.1 – 3.8)	
Linoleic fatty acids (g)	1.0 (0.9 – 1.0)	1.4 (1.3 – 1.4)	1.7 (1.7 – 1.8)	2.4 (2.4 – 3.0)	0.665
Presence of MetS (n)	8	11	6	9	
OR (95%CI)	–	1.4 (0.7 – 2.7)	0.6 (0.3 – 1.5)	1.1 (0.5 – 2.2)	
Linolenic fatty acids (g)	8.2 (7.5 – 8.4)	11.3 (10.9 – 11.7)	14.6 (14.1 – 15.1)	19.7 (20.5 – 23.2)	0.009
Presence of MetS (n)	3	5	12	14	
OR (95%CI)	–	0.5 (0.2 – 1.3)	1.6 (0.9 – 3.1)	2.9 (1.1 – 3.8)	
Saturated fatty acids (g)	15.0 (14.1 – 15.4)	19.2 (19.1 – 19.8)	24.6 (24.4 – 25.4)	32.3 (31.6 – 40.3)	0.270
Presence of MetS (n)	6	7	8	13	
OR (95%CI)	–	0.8 (0.4 – 1.7)	0.9 (0.4 – 1.9)	1.8 (1.0 – 3.4)	
Trans fatty acids (g)	2.6 (2.3 – 2.9)	3.9 (3.9 – 4.6)	5.0 (5.0 – 6.1)	7.5 (7.5 – 9.1)	0.043
Presence of MetS (n)	3	8	11	12	
OR (95%CI)	–	0.9 (0.4 – 1.9)	1.4 (0.7 – 2.7)	1.6 (0.9 – 3.1)	

One-way ANOVA was used to compare means between overweight and obese women and Kruskal-Wallis test, to compare medians between the groups.
MetS: metabolic syndrome; OR: *odds ratio*; 95%CI: confidence interval of 95%.

by Silveira *et al.*[19] were 22 or 23 years old. It is known that MetS rate is higher in older populations[20]. In this sense, a higher prevalence of MetS among the general population of Brazil in comparison to what was observed in the present study was expected. Unfortunately, there are no studies with representative samples in Brazil that investigated the prevalence of MetS using the IDF definition, which hampers comparisons.

The present study did not find that monounsaturated, polyunsaturated or linolenic acids were protective factors against the MetS status. Diets rich in monounsaturated fatty acids have been related to a lower prevalence of chronic disease, and dietary guidelines are increasingly recommending this type of fat, primarily at the expense of saturated fatty acids. Consumption of monounsaturated fatty acids promotes healthy blood lipid profiles, mediates blood pressure, improves insulin sensitivity and regulates glucose levels. Moreover, new data suggest the role for preferential oxidation and metabolism of monounsaturated fat in influencing body composition and decreasing the risk of obesity[21].

In contrast to this evidence, experimental studies that explored the effect of monounsaturated fatty acid consumption on MetS are still inconclusive. Gulseth *et al.*[22] investigated the effects of an isoenergetic change in the quantity and quality of dietary fat on blood pressure in subjects with MetS. The study lasted 12 weeks, and 486 subjects were assigned to one of the 4 diets with distinct fat quantity and quality: 2 high-fat diets rich in saturated fat or monounsaturated fat, and 2 low-fat, high-complex-carbohydrate diets with or without 1 – 2 g/d of very long-chain omega-3 polyunsaturated fatty acid supplementation. There were no overall differences in systolic and diastolic blood pressure or pulse pressure between the dietary groups after the intervention.

Additionally, a study conducted among 548 adults investigated the effects of replacing the amount and type of fat on insulin sensitivity and cardiovascular risk. After the intervention period, which was different for each treatment and varied from 4 to 24 weeks, the study did not support the hypothesis that isoenergetic replacement of saturated fatty acids with monounsaturated fatty acids has a favorable effect on insulin sensitivity[23].

However, caution should be taken when considering the data of the present study. The cross-sectional design does not enable the comprehension of causality. The consumption of ingredients rich in fat is also difficult to estimate. In addition, the three-day food consumption evaluation may not be sufficient to represent a habitual diet.

Results showed that women who had a greater intake of linoleic acid presented a greater risk of MetS. This finding is not compatible with the study conducted by Freire *et al.*[24], in which increased intake (last quintile of intake) of linoleic acid was found to be a protective factor against MetS (OR = 0.50; 95%CI 0.26 – 0.98). However, there have been controversial findings regarding protective factors relating to metabolism. Hekmatdoost[25] did not find any relation between dietary intake of linoleic acid and MetS diagnosis among an Iranian adult population (n = 822).

Linolenic acid intake has also been associated with numerous benefits for MetS[26], but the present study did not find any association between its intake and MetS status. In a sample of 447 Eskimos between the ages of 35 and 74, Ebbensson *et al.*[27] found that linolenic fatty acid intake had a positive influence on components of MetS. This result suggests that linolenic fatty acid intake is a protective factor against the development of MetS. The findings of Freire *et al*.[24] also supported this relationship between linolenic acid intake and MetS.

One explanation for the fact that none of the unsaturated fatty acids under study was associated with benefits for MetS is that all women consumed saturated fat and trans fatty acids above the recommendation, which could not only cause harm, but might also attenuate any benefits from mono or polyunsaturated fatty acids. In addition, all women under study consumed PUFA under the recommendations of WHO (6 – 11%) and this can explain why there were no benefits from its consumption in this sample.

The results of the present study corroborate literature that demonstrates the negative effects of trans fatty acids on MetS development. Its consumption contributes to metabolic dysfunction by adversely affecting circulating lipid levels. It also triggers systemic inflammation, induces endothelial dysfunction and increases visceral adiposity, body weight, and insulin resistance. Dietary trans fatty acids negatively influence hepatocytes, adipocytes, macrophages and endothelial cells[28].

In this study, saturated fatty acids were not associated with MetS status after adjustments for energy. However, they have been related to poor health outcomes in literature. Recently, Mozaffarian[29] noted that saturated fat consumption is no better or worse for health than the average background diet. It is important to further investigate what individuals are eating to replace saturated fatty acids. Individuals have been replacing saturated fatty acids with refined carbohydrates (*e.g.* starches and sugars), which can increase coronary heart disease and other metabolic events.

It should also be noted that the four studied groups (overweight women with and without MetS and obese women with and without MetS) are very similar and might be in different phases or steps of the same disease (adipose tissue accumulation and insulin resistance development). The analysis of the association between MetS and nutrients reflects the association between fatty acids and insulin resistance. Regardless of the presence or absence of MetS, all women had excessive adiposity and similar rates of HOMA-IR, which shows that insulin resistance was very similar among the participants. This might explain why the results were unexpected or so different between the groups according to the type of fatty acids.

Finally, it is important to present limitations of the study. As specified, the cross-sectional design does not enable the comprehension of causality. A three-day consumption report may not be sufficient to evaluate habitual intake, and ingredients rich in fat are usually forgotten by individuals in food consumption reports. The adopted exclusion criteria resulted in a sample that did not represent the female Brazilian population or the residents of São Paulo.

CONCLUSION

There is an association between fatty acid intake and the risk of MetS diagnosis, such that increased quartiles of monounsaturated, polyunsaturated, linoleic and trans fatty acid intake were significantly associated with greater occurrence of MetS among overweight and obese women.

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Received on: 05/27/2014
Final version presented on: 03/18/2015
Accepted on: 04/22/2015