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Trans fatty acid intake among the population of the city of São Paulo, Southeastern Brazil

Consumo de ácidos graxos trans na população da cidade de São Paulo, SP

ABSTRACT

OBJECTIVE: To analyze the monounsaturated and polyunsaturated trans fatty acid intake among the general population.

METHODS: A cross-sectional study was conducted in São Paulo, Southeastern Brazil, in 2003, on a representative sample of 2,298 male and female subjects, including 803 adolescents (12 to 19 years), 713 adults (20 to 59 years) and 782 elderly people (60 years or over). Food intake was measured using 24-hour recall. Mean trans fatty acid intake was described according to gender and age group.

RESULTS: The mean trans fatty acid intake was 5.0 g/day (SE = 0.1), accounting for 2.4% (SE = 0.1) of total energy and 6.8% (SE = 0.1) of total lipids. The adolescents had the highest mean intake levels (7.4 g/day; 2.9% of energy) while the adults and the elderly had similar intake (2.2% of energy for both; 6.4% of lipids and 6.5% of lipids, respectively). The mean trans fatty acid intake among adult and elderly women (approximately 2.5% of energy and 7.0% of lipids) was higher than among men in the same age group. The food item with the highest contribution towards trans fatty acids was margarine, accounting for more than 30% of total intake, followed by filled cookies among adolescents and meat among adults and the elderly.

CONCLUSIONS: The trans fatty acid intake is above the level recommended by the World Health Organization. Replacement of the trans fatty acids in manufactured food items may be an effective measure for reducing trans fatty acid intake in Brazil.

DESCRIPTORS: Dietary Fats. Fatty Acids, Monounsaturated. Trans Fatty Acids. Food Consumption. Diet Surveys. Cross-Sectional Studies. Population groups.

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RESUMO

OBJETIVO: Analisar o consumo de ácidos graxos monoinsaturados e poliinsaturados de configuração trans na população geral.

MÉTODOS: Estudo transversal realizado em São Paulo, SP, 2003, com amostra representativa de 2.298 indivíduos, sendo 803 adolescentes (12 a 19 anos), 713 adultos (20 a 59 anos) e 782 idosos (60 anos ou mais), de ambos os sexos. O consumo alimentar foi medido por meio do recordatório alimentar de 24 horas. Os valores médios de ingestão de ácidos graxos trans foram descritos segundo sexo e faixa etária.

RESULTADOS: O consumo médio de ácidos graxos trans foi de 5,0g/dia (EP=0,1), correspondendo a 2,4% (EP=0,1) do total calórico e 6,8% (EP=0,1) do total de lipídios. Os adolescentes apresentaram as maiores médias de ingestão (7,4g/dia e 2,9% energia), enquanto os adultos e idosos registraram ingestão semelhante (2,2% energia; 6,4% lipídios e 6,5% lipídios, respectivamente). As médias de consumo de ácidos graxos trans entre mulheres adultas e idosas (aproximadamente 2,5% energia e 7,0% lipídios) foram maiores que as médias dos homens de mesma faixa etária. O alimento de maior contribuição para o consumo de ácidos graxos trans foi a margarina, representando mais de 30% do total ingerido, seguido do biscoito recheado para os adolescentes e da carne bovina para os adultos e idosos.

CONCLUSÕES: O consumo de ácidos graxos trans encontra-se acima do preconizado pela Organização Mundial da Saúde. A substituição dos ácidos graxos trans dos alimentos industrializados pode ser uma medida eficaz para a redução do consumo desse tipo de gordura no Brasil.

DESCRIPTORIOS: Gorduras na Dieta. Ácidos Graxos Insaturados. Consumo de Alimentos. Inquéritos Alimentares. Estudos Transversais. Grupos Populacionais.

INTRODUCTION

Over recent decades, epidemiological research has investigated physiological disorders resulting from different intake levels of trans fatty acids (TFAs). These studies have provided strong evidence that trans isomers can cause adverse effects to health, with increased risk of cardiovascular diseases and induction of generalized inflammation.^{2,10,13,14,20} According to Mozaffarian et al,¹⁵ TFAs are involved in the pathophysiology of these diseases and this systemic inflammation by inducing dose-dependent increases in LDL-c/HDL-c ratio, serum triglycerides and lipoprotein Lp(a). They also inhibit the biosynthesis of arachidonic acid, thereby leading to metabolic alterations such as changes in membrane fluidity, endothelial dysfunction and erythrocyte membrane fragility, in addition to stimulating production of the cytokines TNF- α and IL-6 and of C-reactive protein.¹⁵

The World Health Organization (WHO), supported by scientific evidence showing the harmful effects of TFAs, has made recommendations regarding their intake: less than 1% of daily total energy intake, in order to prevent non-transmittable chronic diseases.²³

TFAs are rarely found in a natural state, but are present in the milk and tissues of ruminating animals as a byproduct of biohydrogenation by anaerobic bacteria living in the rumen.^{3,13} Cantwell et al⁷ and Lemaitre et al¹¹ showed that a major source of TFAs in the diet comes from partially hydrogenated vegetable oil in processed foods that are regularly consumed in a typical Western diet, such as in hard and soft margarines, cookies, snacks and bread products.

Given the importance of diet as a factor for health promotion and disease prevention, the present study aimed to analyze the monounsaturated and polyunsaturated TFA intake in the general population.

METHODS

The study data were obtained from a larger research project: a cross-sectional population-based survey on health and living conditions among a representative sample of adolescents, adults and elderly people living in the city of São Paulo, southeastern Brazil, in 2003.

Two-stage cluster sampling of census tracts and households was performed. Census tracts were grouped into three strata based on the percentage of family heads with university schooling. In the first stage, by using probability proportional to size, ten census tracts were drawn from each of the strata, making a total of 30 census tracts for each region. In the second stage, households were drawn from each sector.

The sampling process had the aim of ensuring at least 200 interviews for each of the six domains, composed of three age groups for each gender: 12 to 19 years (adolescents), 20 to 59 years (adults) and 60 years or over (elderly people).

The minimum of 200 interviews enabled estimation of a prevalence of 0.5 with a standard error of 0.06 at a 5% significance level and a design effect of 1.5.

The sample size was then doubled to improve the statistical power, thus comprising 400 subjects per domain. The final sample included 2,400 subjects (both males and females), aged 12 years or over.

Adolescents with total energy intake below 600 kcal/day or above 6,000 kcal/day and adults and elderly people with energy intake below 500 kcal/day or above 4,000 kcal/day were excluded from the analysis.²¹ Thus, a total of 102 interviewees were excluded resulting in a sample of 2,298 subjects (both males and females), comprising 803 adolescents, 713 adults and 782 elderly people.

A structured questionnaire concerning demographic, socioeconomic, family and lifestyle characteristics was applied by trained interviewers at the participants' homes. The main results are shown in Table 1.

The dietary assessment consisted of a single 24-hour recall adapted from Thompson & Byers.¹⁹ The food items reported were quantified in grams, in accordance with Pinheiro et al.¹⁷ and Fisberg & Villar.⁸

The data from the 24-hour recall were entered into the Nutrition Data System for Research (version 5.0, 2007, Nutrition Coordinating Center, Minneapolis, US), which was developed by the University of Minnesota for gathering nutritional information. The primary source of nutritional food values was the US Department of Agriculture (USDA) nutritional composition table, and this was extended with information provided by food manufacturers, the scientific literature and other published food tables. Data from all sources of nutrient information were evaluated for reliability before their inclusion in the database software.

TFA intake was analyzed as the sum of three isomers: hexadecenoic acid (C16:1 7trans), elaidic acid (C18:1 9trans) and linoelaidic acid (C18:2 9,12 cis-trans, trans-cis and trans-trans were included).

The mean TFA intake was described according to gender and age groups. The data on each nutrient were analyzed to determine whether their distribution was normal, using the Kolmogorov-Smirnov test. Skewed nutrient data were transformed into natural logarithm form. Student's t-test and one-way ANOVA with Bonferroni's multiple comparison test were performed to analyze differences in mean TFA intake according to gender and age groups. P-values < 0.05 were considered significant. The data analysis was conducted using Stata, version 8.0, with svy commands for descriptive analysis, and using SPSS, version 10.0.

A list of the major food items accounting for the TFA intake was produced using the weighed-proportions formula developed by Block et al.⁶ Hence, the relative contribution (RC) of a given food item was defined as:

$$RC = \frac{\text{Total TFA grams from a food item } i \times 100}{\text{Total TFA grams from all food items}}$$

The main research project was approved by the Ethics Committee of the Faculdade de Saúde Pública, Universidade de São Paulo. All participants signed the consent form.

RESULTS

The mean energy and fat intakes in the study sample were 1,886 kcal/day and 71 g/day, respectively (Table 2). In all age groups, male subjects, especially adolescents, had higher intake than women did ($p < 0.001$). The mean contribution of fat to energy intake was 33.9%, with higher values observed among adolescents and adult women, compared with elderly subjects ($p < 0.001$).

The mean TFA intake was 5.0 g/day (SE = 0.1), accounting for 2.4% (SE = 0.1) of energy intake and 6.8% (SE = 0.1) of total fat consumed. Comparison of mean TFA intake (g/day) between age groups showed that adolescents had the highest intake and, in particular, male adolescents (Table 3).

Regarding the TFA contribution towards total energy (%E), female adolescents showed higher intake than the intake among elderly women ($p = 0.009$). Comparison of mean TFA intake (%E) within the age groups indicated higher intake among adult and elderly women (Table 3).

The contribution of TFAs to total fat intake was higher among adult and elderly women than among men in the same age group (Table 3). However, no differences in mean intake were found between adult and elderly women or between adult and elderly men.

Table 4 lists ten food items that most contributed towards TFA intake. In all age groups, margarine was the food with the highest contribution, providing more than a third of total TFA consumption, followed by

Table 1. Sociodemographic characteristics and nutritional status of study subjects according to sex and age groups. City of São Paulo, Southeastern Brazil, 2003.

Variable	Adolescents				Adults				Elderly people			
	Male		Female		Male		Female		Male		Female	
	n ^a	%										
Skin color												
White	248	60.3	224	58.2	195	60.2	255	65.7	261	69.2	281	69.6
Black	32	7.8	30	7.8	34	10.5	34	8.8	24	6.4	32	7.9
Others	131	31.9	131	34.0	95	29.3	99	25.5	92	24.4	91	22.5
Nutritional status ^b												
Underweight	15	4.2	5	1.5	8	2.6	15	4.3	70	20.4	62	19.1
Normal weight	274	76.5	261	79.3	165	52.6	198	57.1	161	46.9	134	41.4
Overweight	49	13.7	51	15.5	101	32.2	101	29.1	112	32.7	128	39.5
Obese	20	5.6	12	3.7	40	12.7	33	9.5	-	-	-	-
Head of the family's schooling level												
0 - 4 years	144	35.0	111	29.1	107	33.0	132	34.4	249	66.6	255	64.6
5 - 9 years	106	25.7	112	29.3	85	26.2	106	27.6	46	12.3	53	13.4
10 years or more	162	39.3	159	41.6	132	40.7	146	38.0	79	21.1	87	22.0

^a Missing data were excluded.

^b According to cut-off points of World Health Organization^{22,24} cut-off points for adolescents (2007) and for adults (1995); and according to Nutrition Screening Initiative¹⁶ (1994) for elderly people.

filled cookies among adolescents (11.0%) and meat among adults and elderly people (10.0% and 10.2%, respectively).

DISCUSSION

The mean TFA intake among this population was 5.0 g/day, thus accounting for 2.4% of their daily energy intake. This was above the limit recommended by WHO for preventing non-transmittable chronic diseases (< 1% of total calories).²¹

These findings are similar to those reported by Allison et al,¹ who found mean TFA intake of 5.3 g/day among 11,200 Americans, thus accounting for 2.6% of their daily energy intake.

In a study by Harnack et al¹⁰ that aimed to evaluate trends in TFA intake among adults, a reduction in TFA intake was observed between 1980–1982 and 1995–1997. The mean intake reported for the second period was similar to that found in our study (2.2% of energy intake).

Table 2. Daily energy and fat intake according to sex and age groups. City of São Paulo, Southeastern Brazil, 2003.

Variable	n	Energy (kcal) Mean (SE)	Fats (g/day) Mean (SE)	Fats (% energy) Mean (SE)
Adolescents	803	2,235 (47.3)*	86.7 (2.3)*	34.4 (0.4)
Male	417	2,430 (74.3)**	93.6 (3.7)**	34.4 (0.4)
Female	386	2,034 (51.2)**	79.7 (2.7)**	34.4 (0.5)
Adults	713	1,812 (33.0)*	68.7 (1.4)*	33.9 (0.4)
Male	325	2,083 (42.1)***	77.0 (1.8)***	33.5 (0.5)
Female	388	1,603 (40.0)***	62.3 (2.0)***	33.3 (0.5)***
Elderly people	782	1,537 (24.3)*	56.8 (1.1)****	32.7 (0.3)*
Male	378	1,718 (38.5)****	64.1 (1.9)****	33.1 (0.4)****
Female	404	1,419 (31.5)****	52.0 (1.3)****	32.4 (0.4)****
Total	2,298	1,886 (26.0)	71.0 (1.3)	33.9 (0.3)

SE: Standard error;

* Student's t-test: p<0.05 for genders within the age group;

** ANOVA: p<0.05 compared with adults of the same-sex;

*** ANOVA: p<0.05 compared with elderly of the same-sex;

**** ANOVA: p<0.05 compared with adolescents of the same-sex.

Table 3. Mean intake of monounsaturated and polyunsaturated *trans* fatty acids according to sex and age group. City of São Paulo, Southeastern Brazil, 2003.

Variable	n	Trans fatty acids (g/day)	Trans fatty acids (%energy)	Trans fatty acids (%fats)
		Mean (SE)	Mean (SE)	Mean (SE)
Adolescents	803	7.4 (0.3)*	2.9 (0.1)	8.1 (0.2)
Male	417	7.8 (0.6)**	2.8 (0.1)**	7.9 (0.3)**
Female	386	7.0 (0.4)**	3.0 (0.1)	8.3 (0.4)
Adults	713	4.5 (0.2)	2.2 (0.1)*	6.4 (0.2)*
Male	325	4.6 (0.3)***	1.9 (0.1)	5.7 (0.3)
Female	388	4.3 (0.2)***	2.5 (0.1)	6.9 (0.2)
Elderly people	782	3.8 (0.1)	2.2 (0.1)*	6.5 (0.2)*
Male	378	4.0 (0.2)****	2.0 (0.1)****	5.8 (0.2)****
Female	404	3.7 (0.2)****	2.4 (0.1)****	7.0 (0.2)
Total	2,298	5.0 (0.1)	2.4 (0.1)	6.8 (0.1)

SE: Standard error;

* Student's t-test: $p < 0.05$ for sex within a single age group;** ANOVA: $p < 0.05$ compared with adults of the same-sex;*** ANOVA: $p < 0.05$ compared with elderly of the same-sex;**** ANOVA: $p < 0.05$ compared with adolescents of the same-sex.

In Brazil, the only other study that estimated TFA intake was carried out by Bertolino et al,⁴ who examined the impact of TFA intake on the fat profile of 328 Japanese-Brazilians living in Bauru, southeastern Brazil. A food frequency questionnaire was applied between 1993 and 2000 to assess the usual nutrient intake. In 2000, these Japanese-Brazilians showed mean TFA intake of nearly 3.3% of total energy among men and 3.4% among women. These values were lower than the values reported in 1993. Despite differences between the dietary assessment methods, we found lower TFA intake in our study.

Overall, the mean TFA intake (g/day) decreased with age. Subjects younger than 20 years old had higher mean TFA intake in g/day as well as in terms of percentages of energy and fat. It should be pointed out

that adolescents also had higher mean energy, fat (g/day) and fat contribution towards energy intake, thus suggesting that greater amounts of this macronutrient in their diet led to higher energy and TFA intake values. These findings predict the dietary pattern observed during adolescence, with both high-energy processed foods and trans fats, as shown in Table 4.

The elderly showed lower mean intake of energy, fats (g/day) and TFA (g/day) than all the other age groups. However, the mean TFA intake in terms of energy and fat contribution was similar to that found among adults.

In addition, the ten items that most contributed towards TFAs accounted for about 78% of total trans fat. This is consistent with Cantwell et al,⁷ who identified the food items that most contributed towards TFA intake

Table 4. Percentage contribution of food to monounsaturated and polyunsaturated *trans* fatty acids intake, according to age group. City of São Paulo, Southeastern Brazil, 2003.

Adolescents (n=803)		Adults (n=713)		Elderly (n=782)	
Food item	% Total trans	Food item	% Total trans	Food item	% Total trans
Margarine	36.7	Margarine	34.7	Margarine	36.3
Filled cookie	11.0	Meat	10.0	Meat	10.2
Pizza	6.1	Pizza	6.8	Cracker	8.1
Rolls	5.8	Rolls	6.8	Rolls	7.6
Meat	5.5	Unfilled cookie	5.5	White cake	3.7
Cracker	4.8	Cracker	4.6	(Cooked/fried) Grits	3.4
Microwave popcorn	1.7	White cake	2.8	Pizza	2.8
Whole milk	1.6	Whole milk	2.1	Unfilled cookie	2.7
Butter	1.5	Butter	2.0	Whole milk	2.6
Fried pastries	1.5	French fries	1.7	French fries	2.4

among the Irish population, through a semi-quantitative questionnaire on fat intake. In that population, margarine also accounted for more than 35% of all TFAs consumed. This finding could be attributed to the widespread consumption of this food, along with its elaidic acid content (C18:1 9trans), which is formed by partial hydrogenation of vegetable or marine oils.

Unlike adolescents, the second food that most contributed to TFA intake among adults and elderly was meat. In addition to the TFA isomers analyzed in the present study, other TFAs are present in meat, such as like vaccenic acid (C18:1 11trans) and conjugated linolenic acids (CLA). Both vaccenic acid and CLAs are found naturally in meat and dairy products through the process of bacterial biohydrogenation of linoleic and linolenic acid in the rumen.^{5,9} The findings of meat and cow's milk among the ten food items with the greatest contribution is not because of the high TFA content of these items but, rather, because these foods are often consumed in large amounts. The health effects from natural TFA intake (vaccenic acid and CLA) that have been described in the literature are still inconclusive.^{5,7,9} Some studies using animal models and cell cultures derived from humans have demonstrated several beneficial effects from CLA, in relation to many disorders such as cardiovascular and inflammatory diseases, insulin resistance and different types of cancer. These effects have been attributed to the antiadipogenic, antiatherogenic, anti-inflammatory, antidiabetogenic and anticarcinogenic activities of CLA. However, in most of the clinical studies on humans, CLA did not show these beneficial effects.^{5,9}

Given that the TFA intake in the population studied was above the WHO recommendations, and considering the adverse effects of TFAs on health, it is important to implement public health policies for effective control over TFA intake. The Brazilian Ministry of Health, through its National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária*, ANVISA),

has already established that all labels for processed food products must include information on trans fat content. However, for food items produced in fast food restaurant chains, bakeries or any other facilities where foods are sold with no packaging labels or information, the ANVISA regulation may not succeed in reducing TFA intake.

Placing limits on TFA content in food items was an effective action for reducing TFA intake in Denmark. Danish authorities established a maximum limit of 2% for trans fats in all food items a few years ago. In 2005, the availability of TFA-free margarines significantly reduced TFA intake.^{12,18}

In Brazil, production of TFA-free margarines started in 2005, using technologies such as interesterification of vegetable oils and the use of fractions derived from palm and palm kernel oil.

Eliminating TFAs from margarines can help reduce trans fat intake, but it is essential to replace the TFAs that are present in widely consumed food items such as filled cookies and bakery products. A simulation analysis showed that elimination of TFAs from margarines alone would reduce the TFA intake from 5.0 g/day (SE = 0.2) to 3.1 g/day (SE = 0.1), i.e. from 2.4% (SE = 0.1) to 1.4% (SE = 0.03) of total energy. However, the contribution of TFAs to dietary energy would be still above the recommended levels, which reinforces the urgent need for interventions in Brazil.

In conclusion, our results showed that monounsaturated and polyunsaturated TFA intake was above the level recommended by WHO for prevention of non-transmittable chronic diseases, which are a leading cause of death worldwide. Margarine was the main source of trans fat, accounting for more than one third of the TFAs consumed. Elimination of TFAs from manufactured food items may be an effective intervention for reducing TFA intake in Brazil.

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