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Trabajo Original

Epidemiología y dietética

Contribution of minimally processed and ultra-processed foods to the cardiometabolic risk of Brazilian young adults: a cross-sectional study

Contribución de los alimentos mínimamente procesados y ultraprocesados al riesgo cardiometabólico de adultos jóvenes brasileños: un estudio transversal

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Abstract

Introduction: the simultaneous increase in the prevalence of cardiometabolic diseases and in the consumption of ultraprocessed foods (UPF) suggests a possible relationship between UPF and cardiometabolic risk (CMR).

Objective: to evaluate the association between food consumption, according to the degree of processing, and CMR in young adults.

Methods: this is a comparative cross-sectional study in 120 Brazilian young adults aged 18-25 years, categorized by the presence of CMR. Food consumption was investigated using a semi-quantitative food frequency questionnaire, and classified according to the extent of food processing. Food groups and tertiles in grams of unprocessed, minimally processed (MPF), processed and ultra-processed foods (UPF) were compared using the Kruskal-Wallis test. The associations of food consumption, according to level of processing (MPF and UPF), with CMR components were evaluated using logistic regression models.

Results: a high caloric contribution of UPF was observed in the diet of this study population. The total energy intake from lipids in all foods (p = 0.04) and in UPF (p = 0.03) was greater in the group with CMR. A greater consumption of UPF was a risk factor for abdominal obesity (OR = 1.09; 95 % CI = 1.00-1.18) while a greater consumption of MPF was protective for LDL-c alterations independently of sex, physical activity, and alcohol intake (OR = 0.70; 95 % CI = 0.50-0.98).

Conclusions: UPF contributed to a greater caloric intake from fat in the CMR, and was a risk factor for abdominal obesity. MPF was an independent protective factor for LDL-c alterations.

Keywords:

Metabolic syndrome. Cardiovascular diseases. Foods. Food-processing industry. Fruits.

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Resumen

Introducción: la alta prevalencia de enfermedades cardiometabólicas y el avance de los alimentos ultraprocesados en la dieta sugieren una posible relación entre ellos.

Objetivo: valorar la asociación entre el consumo de alimentos clasificado por el grado de procesamiento y el riesgo cardiometabólico en adultos jóvenes.

Métodos: estudio transversal con una muestra compuesta por 120 jóvenes brasileños de 18 a 25 años, que fueron categorizados según el riesgo cardiometabólico (presencia o ausencia). El consumo de alimentos se evaluó mediante un cuestionario semicuantitativo de frecuencias a partir del que se clasificó la ingesta de acuerdo con el grado de procesamiento. Estos resultados se dividieron en terciles de gramos de alimentos (procesados y mínimamente procesados, procesados y ultraprocessados). Las diferencias de consumo diario de alimentos entre los terciles se compararon por medio del test de Kruskal-Wallis. Se realizó una regresión logística para asociar el grado de procesamiento con los componentes del riesgo cardiometabólico.

Resultados: se observó una alta contribución energética de los alimentos ultraprocesados en la dieta de la muestra estudiada. La ingestión de grasas totales (p = 0,04) y alimentos ultraprocesados (p = 0,03) fue mayor entre el grupo con riesgo cardiometabólico. El consumo de alimentos ultraprocesados fue un factor de riesgo de obesidad abdominal (OR = 1,09; IC 95 %: 1,00-1,18), mientras que el consumo de los mínimamente procesados fue protector frente a las alteraciones del LDL-c, independientemente del sexo, la actividad física y la ingesta de alcohol (OR = 0,70; IC 95 % = 0,50-0,98).

Conclusión: los alimentos ultraprocesados contribuyeron a aumentar la ingesta de grasas y a la obesidad abdominal; en cambio, los alimentos no procesados y mínimamente procesados redujeron los niveles de LDL-c.

Palabras clave:

Síndrome metabólico. Enfermedad cardiovascular. Industria alimentaria. Frutas.

INTRODUCTION

Cardiometabolic risk (CMR) represents a predictive factor for cardiovascular and metabolic disorders, and is characterized by the presence of abdominal obesity, hyperglycemia, hypertriglyceridemia, reduced HDL-c, or hypertension (1). According to the International Diabetes Federation (IDF), a quarter of the world's population has CMR (1). Studies have shown its development in healthy populations, and increasingly in younger age groups, in contrast to the classic profile of its incidence (2,3).

Diet is an important modifiable risk factor for CMR and non-communicable diseases (NCD). Since the beginning of the early history of modern nutrition science, dietary guidelines and food policies have been based on nutrient-focused approaches to address health promotion and disease prevention in the population (e.g., focusing on total fat, saturated fat, or sugar rather than overall food and diet quality) (4). Recent advances in nutrition science support that foods and diet patterns, instead of nutrient-focused metrics, explain many of the effects of diet on NCD (4,5).

There has been a worldwide increase in the intake of ready-made or pre-made products for consumption, the so-called ultraprocessed foods (UPF) (6,7). In Brazil, this scenario has motivated the elaboration of dietary guidelines for the Brazilian population, based on the purpose and extent of food processing, encouraging the consumption of unprocessed and minimally processed food (MPF) to the detriment of UPF (5). Therefore, the investigation of adverse health outcomes according to a food-processing classification seems promising (8).

Although available in the literature, the relationship of UPF with dyslipidemia, CMR, and NCD is still incipient (2,8-10). Only three studies to date have explored the association between UPF and CMR (2,8,11) using the NOVA food classification system, from which derived the new dietary guidelines for the Brazilian population (4). Despite some limitations, these studies found an association between high consumption of ultraprocessed food and CMR (2,8,11).

Further studies discussing the relationship between the degree of food processing and CMR are needed to encourage government agencies to draw up public policies and contribute to the prevention of chronic disease (12). Thus, our study aimed to evaluate the association between food consumption, based on the degree of processing, and CMR in young adults.

METHODS

STUDY DESIGN AND POPULATION

This is a comparative cross-sectional study in a simple random sample. The sample consisted of young adults of both sexes, aged between 18 and 25 years, who were students of health majors at public and private universities in the State of Sergipe, Brazil. The sample was calculated according to Miot (13), with a prevalence among those exposed of 29.6 % (14), a level of significance of 5 %, and a test power of 80 % to estimate a minimum size of 30 individuals for each group. The final sample consisted of 60 individuals in each group, as shown in figure 1. For the exclusion criteria the following was considered: evidence of diseases related to oxidative stress, chronic inflammation, use of medications or nutritional treatments capable of changing the energy balance, inappropriate food consumption, unhealthy lipid profile, impaired plasma insulin levels and glucose metabolism, individuals with unstable body weight in the past six months (allowing 10 % variation above or below), individuals on special diets for at least three months, the conditions of gestation or lactation, and being an elite athlete. Volunteers with missing data were also excluded at the end of the study.

ANALYSIS OF BIOLOGICAL SAMPLES

Blood collection was performed by venipuncture after fasting for 12 hours. Samples with heparin and plasma were separated

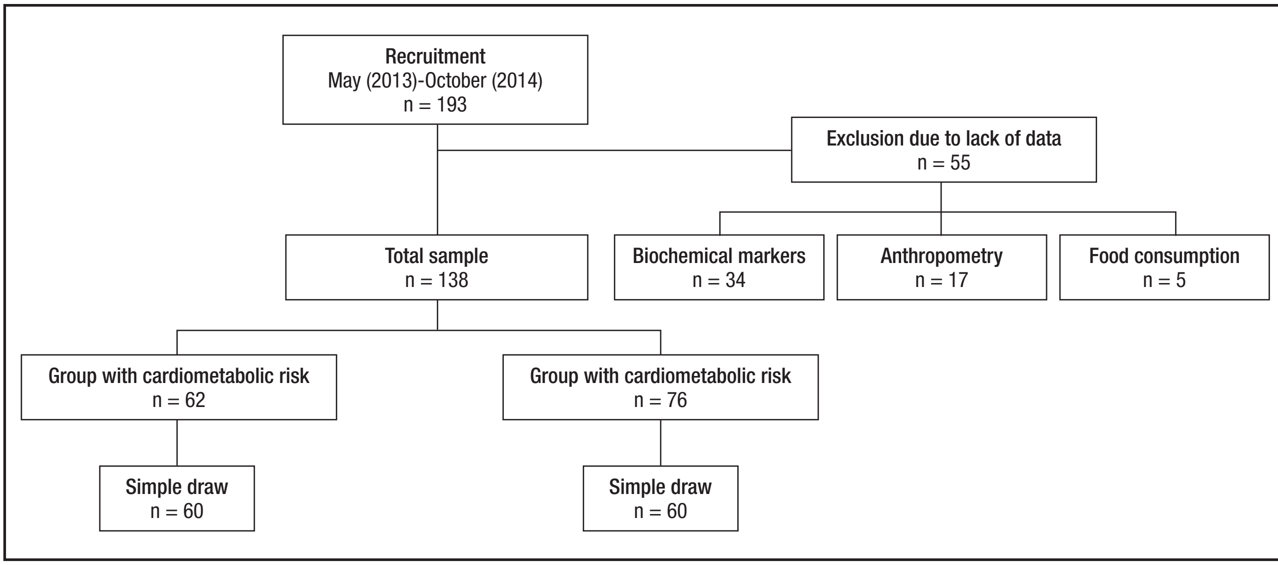

Figure 1.

Flow diagram of the study sample selection.

by centrifugation at 2,465 rpm and a temperature of 5 °C for 15 minutes. The lipidogram and fasting glycemia were analyzed by a colorimetric or turbidimetric method using an automatic analyzer and specific assay kits. Fasting insulin was analyzed by electrochemiluminescence. All analyses were performed at the clinical analysis laboratory of University Hospital of Sergipe, Brazil. The insulin resistance index (HOMA-IR) was calculated using the equation: fasting insulin x fasting glycemia (mmoL) / 22.5.

ANTHROPOMETRIC, BODY COMPOSITION, AND CLINICAL PARAMETERS

Height was measured to the nearest 1 mm using a vertical stadiometer (Exact Height, MG, Brazil). Body weight was measured to the nearest 100 grams using an electronic digital balance (Líder, P 180M, SP, Brazil) (15). Body mass index was calculated from height and weight data.

To measure waist circumference a flexible, inelastic measuring tape was used (16). The triceps skinfold thickness was measured to the nearest 1 mm using a skinfold caliper (Lange caliper, Cambridge Scientific Industries Inc., Cambridge, MD, USA) (17). All measures were performed in triplicate, choosing the coincident values. Body fat and fat-free percentages were obtained by bioelectrical impedance analysis using a quadrupole device (Biodynamics model 310, Washington, DC, USA). Blood pressure levels were measured to the nearest 2 mm Hg using a mercury sphygmomanometer (18).

CARDIOMETABOLIC RISK

The cardiometabolic risk (CMR) components were analyzed according to the criteria of the International Diabetes Federation (1): high waist circumference (≥ 90 cm for males and ≥ 80 cm for women), high levels of triglycerides (≥ 150 mg/dL), low levels of HDL-c (< 40 mg/dL for males and < 50 mg/dL for females), elevated blood pressure (≥ 130 mm Hg systolic or ≥ 85 mm Hg diastolic), and elevated fasting glucose (≥ 100 mg/dL). Individuals with at least one risk component were included in the group with CMR.

FOOD CONSUMPTION AND LIFESTYLE

A validated semi-quantitative food frequency questionnaire (FFQ) (19) was adapted for the study. Household measures were converted into grams or milliliters (20), and the annual consumption of each food was converted to a daily measure. The daily intake of energy, macronutrients, and micronutrients was calculated using national food composition tables (21,22). A proportion of 10 % of sugar was considered for the amount of consumed beverages when the addition of sugar was reported (23). The daily consumption of alcoholic beverages was obtained using this same questionnaire.

Foods were categorized according to their degree of processing (5). After this categorization, the grams of carbohydrates, proteins, and lipids were obtained, and thus the caloric percentage from each food group was also obtained, calculating the total energy value in kilocalories.

The International Physical Activity Questionnaire (IPAQ), as validated in Brazil (24), was used to quantify physical exercise. Smoking was evaluated using the short version of the questionnaire for adults as used by the National Cancer Institute (25).

STATISTICAL ANALYSIS

Considering the non-normal distribution of the data, a Mann-Whitney test was used to compare the groups categorized

Table I. Anthropometric, body composition, clinical, biochemical, and lifestyle characteristics categorized by presence of cardiometabolic risk in young adults (n = 120)

Variables	Presence of CMR		Absence of CMR		*p*-value
	Med	IQR	Med	IQR	
Anthropometry and body composition					
Age (years)	21	3	21	3	0.81
Weight (kg)	61	17	55	10	< 0.01*
Body mass index (kg/m²)	22	6	20	3	< 0.01*
Triceps skinfold thickness (mm)	21	13	20	9	0.20
Body fat (kg)	14	9	13	4	0.10
Body fat percentage (%)	25	8	24	6	0.95
Biochemical markers					
Cholesterol (mg/dl)	158.5	52.5	167.0	52.0	0.72
Non-HDL cholesterol (mg/dl)	114.5	47.0	105.0	32.0	0.13
Low density lipoprotein-c (mg/dl)	97.0	38.5	91.5	28.5	0.35
Very low density lipoprotein (mg/dl)	16.0	11.0	13.0	5.5	< 0.01*
Insulin (mg/dl)	6.8	4.5	6.2	2.7	0.54
HOMA-IR	1.8	1.0	1.2	0.8	0.32
Lifestyle					
Physical activity (min/day)	255	320	235	295	0.91
Alcoholic beverages (ml/day)	0.7	10.0	1.2	6.1	0.99
Smoking (cigarettes/day)	0	0	0	0	1.00
Components of CMR					
Waist circumference (cm)	74.4	12.1	70.7	7.4	< 0.01*
Fasting glycemia (mg/dl)	88.0	13.0	82.0	9.5	< 0.01*
Triglycerides (mg/dl)	79.0	55.5	64.0	33.5	0.14
High density lipoprotein-c (mg/dl)	47.5	13.5	59.0	10.5	< 0.01*
Systolic blood pressure (mm Hg)	110.0	10.0	110.0	10.0	0.26
Diastolic blood pressure (mm Hg)	80.0	10.0	70.0	10.0	< 0.01*

*Med: median; IQR: interquartile range; CMR: cardiometabolic risk; HOMA-IR: insulin resistance index. *Statistical level of 5 %, Mann-Whitney test.*

by the presence of CMR. The comparisons between macronutrients and micronutrients from MPF and UPF, regardless of the presence of CMR, were analyzed using Wilcoxon's test. The comparisons between MPF and UPF consumption tertiles were analyzed using the Kruskal-Wallis test. Odds ratios and 95 % confidence intervals were used to describe the crude and adjusted logistic regression coefficients of the associations of MPF and UPF consumption (exposure variables) with the CMR components (outcome variables). The models were adjusted for sex, physical activity, and alcohol consumption (confounding variables). A Hosmer-Lemeshow goodness-of-fit test was used to assess model fit. A significance level of 5 % was considered. All analyses were performed using the Stata 13.0 software (Stata Corporation, College Station, USA).

ETHICAL ISSUES

The study was approved by the Human Research Ethics Committee of the Universidade Federal de Sergipe (CAAE: 0113.0.107.000-11). In accordance with the principles of the Declaration of Helsinki and the Resolution n. 466/2012 of the National Health Council, all volunteers were informed about the study protocol and signed a consent form.

RESULTS

A total of 89 women (74.2 %) and 31 men (25.8 %) were included in the study sample. The most frequent CMR component was low HDL-c concentration (21.2 %), followed by abdominal obesity (15.0 %), hypertriglyceridemia (9.2 %), hypertension (7.6 %), and hyperglycemia (5.9 %). There were significant differences in CMR components among participants, indicating the categorization of the groups as proposed (Table I).

There was a high caloric contribution of UPF to the diet of this population, although no intergroup statistical differences were found for the CMR group (70.6 %) and the group with no CMR (67.4 %), as shown in table II.

Table II. Daily intake of energy and macronutrients according to food processing level and presence of cardiometabolic risk in young adults (n = 120)

Food groups and macronutrients	Presence of CMR		Absence of CMR		*p*-value
	Med	IQR	Med	IQR	
All foods					
Carbohydrate from TEV (%)	48.8	11,0	51.5	6.9	0.04*
Protein from TEV (%)	17.3	3.8	16.0	4.8	0.36
Lipid from TEV (%)	34.9	11.2	32.9	7.3	0.04*
Carbohydrate (g)	310.7	187.4	326.6	162.7	0.80
Protein (g)	108.9	49.4	99.9	64.5	0.30
Lipid (g)	98.5	46.5	92.9	58.3	0.13
MPF					
TEV (%)	29.4	15.5	32.6	13.6	0.20
Carbohydrate from TEV (%)	36.0	13.8	38.4	19.8	0.13
Protein from TEV (%)	5.9	5.2	7.0	4.0	0.16
Lipid from TEV (%)	6.6	4.8	7.9	4.1	0.23
Grams	711.0	432.1	776.1	411.3	0.43
Carbohydrate (g)	96.1	55.2	112.1	63.0	0.38
Protein (g)	38.5	34.7	43.8	28.7	0.63
Lipid (g)	20.0	18.8	19.1	15.1	0.84
UPF					
TEV (%)	70.6	15.5	67.4	13.6	0.20
Carbohydrate from TEV (%)	33.0	12.5	34.0	11.2	0.36
Protein from TEV (%)	9.3	5.8	8.9	5.2	0.45
Lipid from TEV (%)	26.2	10.2	23.9	5.2	0.03*
Grams	946.9	601.2	881.7	434.7	0.38
Carbohydrate (g)	109.2	89.0	103.6	93.8	0.99
Protein (g)	25.0	22.3	21.9	17.8	0.08
Lipid (g)	33.8	27.5	28.7	24.8	0.06

*Med: median; IQR: interquartile range; CMR: cardiometabolic risk; MPF: in natura and minimally processed foods; UPF: ultraprocessed foods. Percentages derived from the total energy value (TEV) of the diet. *Statistical level of 5 %, Mann-Whitney test.*

No significant differences were observed for daily consumption in grams of macronutrients, or for MPF and UPF groups categorized by the presence of CMR. However, there was a lower percentage of total energy from total carbohydrates and a greater percentage from total lipids in all foods, and in UPFs for the group with CMR. This explains why UPF contributed to the disproportion in fat intake between groups. It was not possible to identify the influence of type of processing on the difference of total carbohydrate percentage between the groups.

It is important to note that despite consuming more total carbohydrates, the non-CMR group did not exceed the maximum value of the Reference Daily Intake as established by the National Research Council's Food and Nutrition Board and the WHO recommendation. Significant differences were observed for the consumption in grams of macro- and micro-nutrients when comparing UPF and MPF ($p < 0.01$), regardless of the presence of CMR (data not shown in the table).

The increased consumption of MPF grams reflected a greater consumption of fruits, natural juices, eggs, and fish. A greater intake of UPF grams was associated with a greater intake of simple pasta, breads, processed meats, cheese, brined vegetables, sweetened and artificial juices, soft drinks, oils and fats, roasted snacks, chips, sandwiches and snacks, sweets and desserts, and traditional dishes (Table III).

In the logistic regression models on the associations of MPF and UPF consumption with cardiometabolic risk components (Table IV), the consumption of UPF was shown to be a risk factor for abdominal obesity in the crude model (OR = 1.09; 95 % CI = 1.00-1.18). The consumption of MPF provided protection against increases LDL-c independently of sex, physical exercise, and alcohol consumption (OR = 0.70; 95 % CI = 0.50-0.98).

DISCUSSION

The results found by this study reveal an important contribution of processed and ultra-processed foods to the diet of Brazilian young adults, regardless of the presence of CMR, which corrobo-

Table III. Daily food consumption according to food processing level in the diet of young adults (n = 120)

	MPF (g)							UPF (g)						
	Tercil 1		Tercil 2		Tercil 3		*p*-value	Tercil 1		Tercil 2		Tercil 3		*p*-value
	< 618.70		618.70-836.67		≥ 836.68			< 768.82		768.82-1068.62		≥ 1068.63		
	Med	IQR	Med	IQR	Med	IQR		Med	IQR	Med	IQR	Med	IQR	
Pasta, roots, and cereals														
Roots and tubers (g)	42.6^{a}	42.3	70.1^{b}	61.1	75.6^{b}	55.9	< 0.01†	50.3^{a}	44.9	56.5^{a,b}	68.2	76.5^{b}	52.5	0.03‡
Flours (g)	40.1	73.6	64.4	86.3	90.0	129.5	0.05	43.8	83.6	64.4	122.3	69.3	87.6	0.18
Simple pasta (g)	16.4	27.1	24.6	37.0	24.6	41.6	0.35	16.4^{a}	26.1	23.8^{a,b}	28.7	32.8^{b}	49.3	< 0.01†
Breads (g)	38.1	46.6	58.6	73.8	56.0	76.8	0.16	34.8^{a}	38.6	52.4^{a,b}	70.2	85.7^{b}	75.4	< 0.01†
Rice (g)	53.6^{a}	50.0	100.0^{a,b}	50.0	100.0^{b}	121.5	< 0.01†	57.1^{a}	50.0	100.0^{a,b}	71.4	100.0^{b}	137.6	0.02‡
Meat and eggs														
Red meat and poultry (g)	85.1^{a}	50.3	106.7^{a}	70.2	142.9^{b}	117.3	< 0.01†	94.2^{a}	59.3	114.2^{a,b}	61.4	126.8^{b}	127.5	< 0.01†
Fishes (g)	8.7^{a}	14.2	10.8^{a}	14.2	18.6^{b}	22.0	< 0.01†	11.1	15.8	13.0	14.2	17.3	29.4	0.64
Eggs (g)	14.3^{a}	23.6	14.3^{a}	22.7	21.4^{b}	35.7	< 0.01†	14.3	23.6	14.3	20.2	21.4	25.0	0.08
Visceras (g)	2.0	6.9	2.0	7.8	4.3	8.6	0.62	2.0	5.1	2.0	4.9	6.0	8.6	0.13
Processed meats (g)	11.4	10.0	5.5	8.8	11.4	13.7	0.28	4.7^{a}	9.7	5.7^{a}	9.0	11.4^{b}	11.4	< 0.01†
Dairy products														
Milks (ml)	35.4^{a}	89.9	112.0^{b}	168.0	252.6^{b}	429.4	< 0.01†	50.2^{a}	110.1	114.3^{b}	197.7	128.8^{b}	429.8	< 0.01†
Vegetable milk (ml)	0.0	0.0	0.0	0.0	0.0	0.0	0.37	0.0	0.0	0.0	0.0	0.0	0.0	0.37
Cheese (g)	17.7	33.8	20.0	37.4	19.0	60.2	0.89	10.6^{a}	19.0	20.2^{a,b}	41.8	25.3^{b}	59.3	< 0.01†
Dairy drinks (ml)	68.0^{a}	80.6	87.8^{a,b}	124.4	148.2^{b}	154.1	< 0.01	53.4^{a}	72.6	87.4^{b}	101.3	171.3^{c}	167.9	< 0.01†
Legumes														
Beans (g)	40.0^{a}	35.0	100.0^{b}	91.7	85.0^{b}	95.0	< 0.01†	50.0^{a}	35.0	75.0^{b}	100.0	70.0^{a,b}	96.7	0.03
Brined legumes (g)	1.0	2.3	1.5	4.3	2.3	7.7	0.15	1.2^{a}	2.1	1.2^{a}	2.0	3.0^{b}	8.9	< 0.01†
Vegetables														
Vegetables (g)	70.2^{a}	81.3	98.0^{a,b}	78.2	132.2^{b}	145.3	< 0.01†	75.2^{a}	85.4	98.0^{a,b}	90.9	122.7^{b}	133.4	0.01‡
Fruits														
Fruits and natural juices (g/ml)	245.1^{a}	262.3	332.7^{a,b}	365.6	431.3^{b}	148.8	< 0.01†	278.6	354.0	344.2	360.5	373.5	280.4	0.53
Sweetened juices (ml)	169.6	205.4	228.5	218.5	207.3	310.0	0.84	94.0^{a}	106.0	194.8^{b}	192.0	359.6^{c}	278.8	< 0.01†
Oils and fats														
Oils and fats (g/ml)	9.9	15.9	11.7	16.4	12.1	17.0	0.22	8.9^{a}	15.0	10.1^{a,b}	16.2	19.0^{b}	14.8	0.03‡
Fried pastries (g)	3.3^{a}	5.0	6.7^{b}	10.5	6.7^{a,b}	22.0	0.03‡	3.3^{a}	5.0	3.3^{a}	5.2	10.0^{b}	21.9	< 0.01†
Baked pastries (g)	3.3	6.7	6.7	6.7	4.2	14.4	0.47	3.3^{a}	5.5	3.3^{a}	3.3	8.3^{b}	20.9	< 0.01†
Sugars and candies														
Cookies and cakes (g)	27.5^{a}	36.7	46.0^{b}	43.0	47.0^{a,b}	40.9	0.03‡	20.8^{a}	37.0	34.6^{a}	33.0	56.8^{b}	54.6	< 0.01†
Candies and desserts (g)	38.4	53.5	56.7	83.8	51.9	40.4	0.17	30.2^{a}	32.8	46.3^{b}	44.1	77.7^{c}	68.9	< 0.01†
Artificial juices (ml)	7.3	34.3	8.0	30.3	20.0	51.9	0.74	2.7	13.3	8.0	57.1	26.3	68.4	< 0.01†
Soft drinks (ml)	20.6	55.7	24.0	77.7	33.1	66.5	0.50	8.0^{a}	30.7	20.0^{a}	45.3	68.5^{b}	185.7	< 0.01†
Others														
Chips (g)	3.3	3.1	3.9	9.1	4.7	6.2	0.56	2.3^{a}	3.1	3.3^{a}	7.4	6.7^{b}	12.1	< 0.01†
Ready-to-eat foods (g)*	2.5	3.7	1.3	10.6	1.7	5.8	0.81	1.7	3.3	2.1	6.3	1.7	10.5	0.77
Sandwiches and snacks (g)	27.2	31.8	38.5	47.2	37.1	45.8	0.11	21.1^{a}	23.2	35.8^{a,b}	40.1	45.5^{b}	72.9	< 0.01†
Alcoholic beverages (ml)	0.9	7.3	0.8	7.5	1.6	7.5	0.96	0.4	3.0	0.8	5.7	3.7	20.0	0.06
Stuffed pasta (g)	9.3^{a}	23.3	18.7^{b}	18.7	18.7^{a,b}	23.3	0.03‡	9.3^{a}	20.2	9.3^{b}	18.7	25.2^{a}	21.3	< 0.01†
Sauces (g)	0.3^{a}	0.9	0.7^{b}	2.0	1.4^{a,b}	3.5	0.04‡	0.2^{a}	0.6	0.5^{a}	1.8	3.3^{b}	4.6	< 0.01†
Traditional dishes (g)**	10.6	25.2	18.3	30.7	18.9	32.6	0.16	10.7^{a}	16.8	16.7^{a,b}	32.2	22.1^{b}	32.2	0.02‡
Coffee (ml)	17.1	92.8	42.8	99.6	16.1	100.0	0.68	16.1	53.6	46.4	83.8	42.8	149.2	0.20

*MPF: in natura and minimally processed foods; UPF: ultra-processed foods; Med: median; IQR: interquartile range. *Noodles and cereal bar; **Tapioca, fritada, feijoada. †Statistical level of 1 %; ‡Statistical level of 4 %; Kruskal-Wallis test. Values on the same line with the same letter are not significantly different.*

Table IV. Crude and adjusted associations of MPF and UPF consumption with cardiometabolic risk and lipid profile in young adults (n = 120)

	Waist circumference		Fasting glycemia		Triglycerides		Total cholesterol		LDL-c		HDL-c		SBP		DBP	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
MPF (g)																
Crude model	0.92	0.78-1.08	0.94	0.74-1.19	1.10	0.95-1.29	0.97	0.85-1.11	0.74	0.54-1.02	0.90	0.78-1.04	1.05	0.82-1.36	0.99	0.86-1.17
Adjusted model*	0.87	0.73-1.04	0.89	0.69-1.16	1.08	0.92-1.27	0.94	0.81-1.08	0.70	0.50-0.98†	0.90	0.78-1.04	1.06	0.73-1.54	0.95	0.79-1.15
UPF (g)																
Crude model	1.09	1.00-1.18†	1.01	0.88-1.16	1.03	0.93-1.14	0.94	0.85-1.04	0.86	0.70-1.07	0.98	0.90-1.07	1.09	0.91-1.29	1.03	0.92-1.15
Adjusted model*	1.05	0.95-1.15	0.98	0.83-1.16	0.97	0.84-1.12	0.90	0.79-1.02	0.79	0.60-1.03	0.98	0.89-1.08	0.97	0.76-1.24	0.97	0.85-1.12

*OR: odds ratio; 95 % CI: 95 % confidence interval; MPF: in natura and minimally processed foods; UPF: ultraprocessed foods; LDL-c: low density lipoprotein cholesterol; HDL-c: high density lipoprotein cholesterol; SBP: systolic blood pressure; DBP: diastolic blood pressure. *Adjusted for sex, physical activity, and alcoholic beverages; †p < 0.05.*

rates data already found for a young population in Brazil regarding a daily caloric contribution of 51.2 % from UPF (5). Meanwhile, a report of the Pan American Health Organization (PAHO) pointed out a 26.7 % increase in sales for beverages and UPFs in Latin America while these sales decreased by 9.8 % in North America (6).

The relationship between UPF and non-communicable chronic diseases is due to the poor nutritional quality of these foods and their great content in fats and sugars (6). A study evaluating the relationship between total macronutrients and clinical outcomes (26), not considering the degree of processing of the consumed foods, did not observe an influence of lipids or carbohydrates from UPF on their total intake or on the manifestation of CMR as we found.

A high consumption of fat is associated with dyslipidemia (3,27) and other non-communicable chronic diseases, especially cardiovascular diseases, which are the main cause of mortality in the world's population (28). UPFs are rich in fats, especially in saturated and trans fats, which make food more attractive and palatable (6). At the same time fats attract the population to the consumption of UPF, they contribute to vascular endothelial dysfunction prior to dyslipidemias, atherosclerosis (27) and other diseases, including those related to cognitive disorders such as Alzheimer's disease and dementia (29).

Processed meats, as well as fatty and processed snacks, are sources of saturated fats and are associated with an increased risk of cardiovascular disease (30). In 2015 the WHO pointed out the consumption of processed meats as a determinant of colorectal carcinogenesis in humans (31). Although traditional dishes represent a cultural value of the region, their greater consumption may be related to an increase in UPF intake since *feijoada* and *fritada* have ingredients with high fat and energy contents.

UPF generally include a great amount of added sugar. In the US diet, the content of added sugars in UPF was eightfold higher than in processed foods, and fivefold higher than in MPF and processed culinary ingredients grouped together (32). There is already evidence of a relationship of added and refined sugar with coronary artery disease. This alerts to the importance of excessive sugar consumption as a potential risk factor for cardiovascular diseases besides saturated fat.

A study evaluating the association between dietary patterns and metabolic syndrome in healthy adults found a positive association of sugar and fast-food consumption with LDL-c levels (3). A Brazilian cohort of 3- to 4-year-old children observed that UPFs were predictors of increases in total cholesterol and LDL-c from pre-school to school age. Foods with the greatest energy contribution in the above-mentioned study included breads, crackers, salty snacks, and candies (9). Meanwhile, another cohort study in Brazil observed that the caloric contribution of MPF had been reduced by 5.1 percentage points between 1987 and 2009 (33).

Recommendations to prevent cardiovascular disease advise the consumption of fish, fruits and vegetables due to their independent protective effect, which becomes greater when combined with or making up eating patterns like the Mediterranean diet (34,35). In a recent systematic review and meta-analysis, fish and fruits were among the ten foods indicated as cardiometabolic protectors. This same study also highlighted processed meats and sugar-sweetened beverages as harmful to cardiometabolic health (35). According to some explanations the protective role of eggs is promoted by unsaturated phospholipids that contribute to lowering cholesterol and blood pressure levels (36).

The number, size, and density of LDL-c particles in serum total cholesterol may influence its relationship with cardiovascular disease. The origin and amount of saturated fat and simple sugars in foods affect via different paths LDL-c levels and cardiovascular health. Because processed and ultraprocessed foods offer a greater nutritional imbalance and are rich sources of saturated fats and simple sugars, their consumption may promote a reduction of LDL-c particle size, with LDL-c thus becoming more susceptible to oxidation and atherogenic, thrombotic, and inflammatory processes (37).

A randomized controlled trial tested beverages with different sugar concentrations in healthy adults, and observed that even low and moderate concentrations of sugar reduced the size of LDL-c particles and consequently increased their atherogenic power (38). Furthermore, controlling or reducing LDL-c levels is a well-established strategy to prevent cardiovascular outcomes such as the already known effect of LDL-c reduction on the onset of mini stroke (27).

In addition to characteristics such as practicality and palatability, strong media influence is another factor that motivates a greater consumption of UPF. In Brazil, beverage advertising is the third largest category of television commercials, where UPF represent 60.7 % of advertisements versus only 7.0 % related to MPF (39).

The increased consumption of fruits and unsweetened juices observed in the MPF diet may have substantially contributed to the protection conferred against LDL-c in the population of this study. Likewise, we believe that the higher consumption of fish has also protected against LDL-c alteration in the MPF group. According to the degree of food processing, the study reinforces the notion that healthy diets should be based on a low consumption of UPF and, especially, on a high daily consumption of MPF for the prevention of unfavorable clinical outcomes.

This study had some limitations that must be considered. Because this was an observational cross-sectional study, a causal association of MPF and UPF consumption with cardiometabolic risk cannot be inferred. Also, any generalization of the findings beyond the overall and male populations must be cautious since the majority of the study sample was made up of females (74.2 %). The FFQ method employed in this study to investigate food intake may also represent another limitation. Although FFQs are relatively inexpensive and easily applied, their success depends on the memory of the respondent, and requires well-trained investigators to obtain accurate estimates of the portions and frequencies consumed. However, this method provided reliable estimates of the average dietary intake of the study population (40).

To minimize the risk of bias in the study, the sample was randomly selected, protocols and training were used to optimize data collection, and only one researcher performed all anthropometric measures in triplicate for better accuracy of the measured values. To minimize the risk of bias in the collection of food consumption, a food photography gallery was used to help participants report the portions and quantities consumed.

CONCLUSIONS

Fats from UPF contributed to a greater total energy value in the group with CMR. Consumption of UPF was shown to be a risk factor for abdominal obesity whereas consumption of MPF was an independent protective factor against changes in LDL-c levels. Our results support the need for more studies on this perspective, as well as public policies targeting diets high in unprocessed and MPF and low in UPF, in order to contribute to the prevention and control of cardiometabolic diseases in young populations.

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