Degree of food processing and its relationship with overweight and body adiposity in Brazilian adults

Grau de processamento de alimentos e sua relação com sobrepeso e adiposidade corporal em adultos brasileiros

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ABSTRACT

Objective

To check the relationship of the degree of food processing with overweight and body adiposity in Brazilian adults.

Methods

Cross-sectional study with 670 adults (334 women and 336 men) aged 20-59 years in *Viçosa, Minas Gerais*, Brazil, based on population data collected using a questionnaire, 24-hour dietary recall interview, and anthropometric evaluation.

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Consumed foods were categorized into four groups: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods. Poisson regression models were used to assess the relationship between degree of food processing and overweight and body adiposity.

Results

The contribution of unprocessed or minimally processed foods to total energy intake was a protective factor for overweight in all quartiles. The contribution of ultra-processed foods to total energy intake was a risk factor for overweight in the highest quartile (prevalence ratio, 1.308; 95% confidence interval, 1.085-1.577). High energy intake from ultra-processed foods was a risk factor for excess adiposity in the highest quartiles.

Conclusion

Consumption of ultra-processed foods is associated with overweight and excess adiposity, whereas consumption of unprocessed and minimally processed foods is a protective factor for overweight.

Keywords: Adult. Eating. Food guide. Industrialized foods. Obesity.

R E S U M O

Objetivo

O objetivo deste estudo foi verificar a relação entre o grau de processamento de alimentos e sobrepeso e adiposidade corporal em adultos brasileiros.

Métodos

Estudo transversal com 670 adultos (334 mulheres e 336 homens) com idades entre 20 e 59 anos, em Viçosa, Minas Gerais, Brasil, com base em dados populacionais coletados por meio de questionário estruturado, entrevista de recordatório alimentar de 24 horas e avaliação antropométrica. Os alimentos consumidos foram categorizados em quatro grupos: alimentos não processados ou minimamente processados, ingredientes culinários processados, alimentos processados e alimentos ultraprocessados. Modelos de regressão de Poisson foram utilizados para avaliar a relação entre o grau de processamento dos alimentos e excesso de peso e de adiposidade corporal.

Resultados

A contribuição de alimentos não processados ou minimamente processados para a ingestão total de energia foi um fator protetor para o excesso de peso em todos os quartis. Por outro lado, a contribuição dos alimentos ultraprocessados para a ingestão total de energia foi um fator de risco para o excesso de peso no quartil mais alto (razão de prevalência 1,308; intervalo de confiança de 95%, 1,085-1,577). O alto consumo de energia de alimentos ultraprocessados foi um fator de risco para o excesso de adiposidade nos quartis mais altos.

Conclusão

O consumo de alimentos ultraprocessados está associado ao excesso de peso e excesso de adiposidade, enquanto o consumo de alimentos não processados e minimamente processados é um fator protetor para o excesso de peso.

Palavras-chave: *Adultos. Ingestão de alimentos. Guias alimentares. Alimentos industrializados. Obesidade.*

I N T R O D U C T I O N

Obesity is characterized as a chronic disease, of complex etiology and excessive accumulation of body fat. It is a major public health problem worldwide and a risk factor for several diseases [1,2]. The increase in obesity prevalence may be attributed to many factors, including unhealthy dietary habits.

Some studies evaluated the relationship between overweight and the degree of food processing [3-6]. Monteiro [7] was the first to explore the possibility that the increase in obesity prevalence is related to the high intake of processed and ultra-processed foods. The author proposed a food classification system based on the nature, degree, and purpose of food processing. Foods are grouped into four categories: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods [8-10]. A new classification of food and health began to emerge.

The purpose main of ultra-processing is to create ready-to-eat, ready-to-drink, or ready-to-heat products. These energy-dense foods contain high levels of sodium, free and added sugars, saturated fats, and trans fats and are low in fibers, micronutrients, bioactive compounds, and proteins [11-14]. High palatability, omnipresence, and aggressive marketing strategies contribute to the high consumption of ultra-processed foods [15,16].

There has been a growing tendency to replace traditional foods with ready-to-eat foods in middle- and low-income countries, especially from the 1980s onward [8]. This behavior may be considered obesogenic, as it can lead to poor dietary habits [11,13]. Intake of convenience foods has increased worldwide compared to obesity [17,18]. Such tendencies have also been observed in Brazil, where studies associated the intake of ultra-processed foods with an increase in obesity prevalence [19-20]. A Brazilian cohort study identified that consumption of ultra-processed foods increased the risk of weight and waist circumference gain by 20-30% [21].

Research on the new food classification system is still incipient. Further studies are essential to establish whether the intake of highly processed foods is a risk factor for obesity, about everything abdominal obesity. In Brazil, few studies focused on the relationship between the degree of food processing and adiposity/abdominal adiposity in adults [6,19-23]. This study aims to check the relationship between the intake of processed foods and overweight and body adiposity in Brazilian adults.

METHODS

This cross-sectional study was carried out by the research group *Estudos sobre Saúde e Alimentação de Viçosa* (ESA/*Viçosa*, Studies on Health and Dietary Habits in *Viçosa*). Female and male adults aged 20-59 years living in urban areas in *Viçosa, Minas Gerais*, Brazil, were eligible to participate. Pregnant women, bedridden individuals, amputees, individuals who were unable to answer the questionnaire because of cognitive or intellectual disabilities, and those who did not participate in the body composition assessment were excluded from the study. The final sample included 670 individuals. Sample size was calculated using OpenEpi.

The study was approved by the *Comitê de Ética em Pesquisa com Seres Humanos da Universidade Federal de Viçosa* (Human Research Ethics Committee of the Federal University of *Viçosa*), under protocol CAAE n. 42073314.0.0000.5153. All subjects signed an informed consent form.

Data were collected between 2012 and 2014 in two stages. Home visits were made by a trained team to administer a structured questionnaire containing socio-demographic and behavioral questions and conduct a 24-hour dietary recall interview. Then, subjects were invited to participate in the body composition assessment. The description of the research method is presented by Segheto *et al*. [24].

The United States Department of Agriculture (USDA) Automated Multiple-Pass Method (AMPM) was used for collecting 24-hour food recalls. This tool applies a five-step approach to increase recall (quick list, forgotten-foods, time-and-occasion, detail cycle, and final probe) [25]. A food photograph album and food labels were used to assist in the estimation of portion sizes [26]. Food consumption was reported in common household measures and converted to grams or milliliters using a conversion table. Data were analyzed using Brasil-Nutri® software, developed for the 2008-2009 Consumer Expenditure Survey [27].

Foods were categorized into four groups according to their degree of processing: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods [8]. Body composition was identified by dual-energy X-ray absorptiometry (DPX-IQ 5781, Lunar Radiation,

Madison, WI, USA). Measurements were taken by an experienced technician, with individuals in the fasted state and in dorsal decubitus. Body fat was estimated using Lohman's equation [28]. Excess adiposity was defined as total body fat ≥25% for men and ≥32% for women [29].

Body weight was measured to the nearest 0.1kg using a digital scale (BC-554 Ironman®, Tanita, Tokyo, Japan), and height was measured to the nearest 0.1cm using a stadiometer (Welmy, *Santa Bárbara do Oeste*, SP, Brazil). The Body Mass Index (BMI) was calculated by dividing the weight (kg) by the height squared (m²) and analyzed according to World Health Organization criteria (normal weight, BMI=18.5-24.9; overweight, BMI≥25.0) [30].

The following socio-demographic variables were analyzed: sex (female and male), age (20-29, 30-39, 40-49, and 50-59 years), and level of education (0-3, 4-7, and ≥8 years). Behavioral variables included self-reported smoking status (non-smoker, current smoker, or ex-smoker), level of physical activity, and screen time [31]. Physical activity level was assessed using the long version of the last 7-day recall International Physical Activity Questionnaire (IPAQ), validated for the Brazilian population [32]. Screen time was defined as the time spent watching television or using a computer for entertainment on weekdays and weekends. Spending 5 hours or more a day on screen-based recreational activities was considered excessive [33].

Data were weighted to the sex, age, and education distribution of the population of *Viçosa* (MG) using the svy command in STATA version 13.1 [34]. Descriptive statistical analyzes were performed to summarize socio-demographic and behavioral data, and results are presented as relative frequencies. The contribution percentage of each food group to the daily energy intake was calculated, and results are expressed as mean±standard deviation. Associations between quartiles of energy contribution percentage, overweight, and body adiposity were analyzed by Poisson regression. The prevalence ratio and confidence intervals (95%CI) were determined. All variables that met the selection criterion ($p<0.20$) were included in the model using backward selection (sex, age, education, and screen time). Additionally, the χ^2 test for trends was used to assess linear trends in quartiles of food consumption ($p<0.05$).

RESULTS

Of the 670 participants, 50.1% were men, 26.3% were 30-39 years old, and 69.6% had at least 8 years of formal education. Most individuals were non-smokers (64.9%), physically inactive (75.6%), and did not have excessive screen time (91.1%). Overweight was observed in 44.4% of subjects and excess adiposity in 58.0% (Table 1).

The mean daily energy intake of the study population was 10383.26±4793.89 Joules/day, 57.90% (6041.5 Joules/day) of which was provided by unprocessed or minimally processed foods, 3.40% (314.0 Joules/day) by processed culinary ingredients, 14.0% (1482.1 Joules/day) by processed foods, and 24.60% (2382.2 Joules/day) by ultra-processed foods (Table 2). The most relevant frequently reported unprocessed and minimally processed foods were meat, fish, eggs, rice, beans, and milk. The most frequently reported processed foods were wheat cake (6.64%), followed by alcoholic beverages, cheese, processed meats, and canned fruits and vegetables. Among ultra-processed foods, the most frequently reported were breads and sweet/salty biscuits (8.50%), finger foods and fast foods (4.10%), candies (3.30%), and sausages (2.50%).

Overweight adults had a mean daily energy intake of 9960.40±259.58 Joules/day; 56.6% of the energy intake came from unprocessed or minimally processed foods, 3.7% from processed culinary ingredients, 15.1% from processed foods, and 24.4% from ultra-processed foods. Adults with excess adiposity had a mean daily energy intake of 99,353.31±272.14 Joules/day, 56.2% of which was provided by unprocessed or minimally processed foods, 3.1% by processed culinary ingredients, 17.7% by processed foods, and 23.0% by ultra-processed foods.

Table 1 – Demographic, socioeconomic, behavioral, and food consumption characteristics of the study population. Study on Health and Dietary Habits, *Viçosa* (MG), Brazil, 2012-2014.

Variable	Relative frequency (%)	95%CI
Sex		
Male	50.1	45.3-54.9
Female	49.9	45.0-54.6
Age (years)		
20-29	23.8	16.7-32.7
30-39	26.3	21.7-31.4
40-49	24.2	19.5-29.7
50-59	25.7	20.2-31.7
Education (years)		
0-3	13.6	7.6-23.1
4-7	16.8	12.3-22.6
≥8	69.6	58.4-78.7
Smoking		
Non-smoker	64.9	57.6-71.5
Smoker or ex-smoker	35.1	23.3-46.1
Level of physical activity in leisure		
Not adequate	75.6	72.1-78.6
Adequate	24.4	21.3-27.8
Screen time		
Non-excessive	91.1	87.8-93.5
Excessive	8.9	6.4-12.2
Nutritional status		
Adequate	50.6	43.6-57.6
Overweight	49.4	42.3-56.3
Excess body fat		
No	38.0	32.4-43.9
Yes	62.0	56.0-67.5

Note: CI: Confidence Interval.

Table 2 – Distribution of total daily energy intake according to food groups and subgroups and contribution percentage considering overweight and excessive body adiposity in adults. Study on Health and Dietary Habits, *Viçosa* (MG), Brazil, 2012-2014.

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Food groups and subgroups	Mean energy intake					
	Overall n=670		Overweight n=298		Excessive body adiposity n=389	
	%	SD	%	SD	%	SD
Unprocessed or minimally processed foods	57.92	1.29	56.65	1.92	56.16	1.84
Rice	10.78	0.34	11.70	0.46	10.22	0.46
Beans	7.49	0.27	7.35	0.32	7.57	0.30
Meat, fish, and eggs	14.37	0.46	15.23	0.97	15.17	0.63
Fruits[a]	5.90	0.36	5.22	0.44	5.54	0.49
Vegetables[b]	4.77	0.31	3.80	0.63	3.88	0.67
Milks	11.17	0.88	10.02	1.46	10.32	1.31
Coffees and teas	0.23	0.08	0.14	0.03	0.18	0.04
Other grains[c]	3.05	0.25	3.10	0.48	3.14	0.47
Other processed or minimally processed foods[d]	0.15	0.04	0.08	0.03	0.10	0.03
Spices	0.01	0.01	0.01	0.01	0.01	0.01
Processed culinary ingredients	3.43	0.19	3.74	0.35	3.07	0.27
Sugar, salt, oil, vinegar, olive oil, and butter	3.43	0.19	3.74	0.35	3.07	0.27
Processed foods	14.00	0.70	15.13	0.87	17.74	0.73
Cheeses	1.70	0.21	2.41	0.30	2.18	0.31
Wheat cake	6.64	0.32	6.04	0.60	8.41	0.58

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| Food groups and subgroups | Mean energy intake | | | | | |
| | Overall n=670 | | Overweight n=298 | | Excessive body adiposity n=389 | |
	%	SD	%	SD	%	SD
Processed meat[e]	1.08	0.20	1.30	0.49	1.44	0.53
Canned fruits and vegetables	0.23	0.05	0.31	0.08	0.33	0.08
Fermented alcoholic beverages	4.35	0.66	5.07	0.89	5.56	0.94
Ultra-processed foods	24.65	1.32	24.45	1.73	23.00	1.70
Sweet/salty biscuits and breads	8.59	0.54	7.93	0.67	6.89	0.59
Hard liquors	0.63	0.16	0.53	0.28	0.59	0.32
Soft drinks and industrialized fruit juices	2.68	0.15	2.39	0.28	2.39	1.70
Candies[f]	3.39	0.30	3.64	0.57	3.26	0.62
Finger foods and fast foods	4.17	0.45	4.32	0.62	4.14	0.62
Sausages	2.51	0.30	3.18	0.63	3.50	0.67
Breakfast cereals[g]	1.19	0.09	1.04	0.14	1.21	0.15
Sugared milk beverages	0.84	0.08	0.63	0.10	0.59	0.07
Pastries[h]	0.65	0.11	0.79	0.14	0.39	0.12

Note: [a]Includes fresh fruit juice; [b]Includes vegetables, roots, and tubers; [c]Corn, oat, wheat, flours, and grain-based foods such as noodles; [d]Nuts and seeds, natural yogurt, lentil, soy-based foods, and food items composed of several mixed foods; [e]Tuna, sardine, and bacon; [f]Hard candies, pies, chocolate, and jelly; [g]Breakfast cereals, sauces, and margarine; [h]Instant noodles, lasagna, instant dry soup mixes, and popcorn.
SD: Standard Deviation.

Regression analysis revealed a relationship between overweight and the contribution percentage (in quartiles) of unprocessed or minimally processed foods to daily energy intake. The intake of unprocessed or minimally processed foods was a protective factor for overweight. On the other hand, the percentage contribution (in quartiles) of ultra-processed foods was considered a risk factor for overweight and excess adiposity. The prevalence ratio of overweight increased with increasing percentage contribution of ultra-processed foods (Table 3).

Table 3 – Relationship between overweight and excessive body adiposity in adults and the contribution percentage of food groups and subgroups. Study on Health and Dietary Habits, *Viçosa* (MG), Brazil, 2012-2014.

| Food groups | Overweight | | Excessive body adiposity | |
	Prevalence ratio	95%CI	Prevalence ratio	95%CI
Unprocessed or minimally processed foods				
Q1	Reference		Reference	
Q2	0.742	0.565-0.976	0.910	0.809-1.023
Q3	0.705	0.563-0.884	0.835	0.692-1.001
Q4	0.762	0.574-0.913	0.877	0.754-1.021
Processed culinary ingredients				
Q1	Reference		Reference	
Q2	0.807	0.641-1.015	0.881	0.785-0.988
Q3	0.803	0.608-1.060	0.849	0.720-1.000
Q4	0.900	0.719-1.125	0.910	0.797-1.039
Processed foods				
Q1	Reference		Reference	
Q2	1.033	0.7894-1.353	1.087	0.926-1.277

Table 3 – Relationship between overweight and excessive body adiposity in adults and the contribution percentage of food groups and subgroups. Study on Health and Dietary Habits, *Viçosa* (MG), Brazil, 2012-2014.

Food groups	Overweight		Excessive body adiposity	
	Prevalence ratio	95%CI	Prevalence ratio	95%CI
Q3	0.964	0.814-1.142	1.003	0.865-1.164
Q4	0.907	0.636-1.294	1.008	0.883-1.151
Ultra-processed foods				
Q1	Reference		Reference	
Q2	1.002	0.759-1.321	1.027	0.905-1.165
Q3	1.038	0.779-1.381	1.094	1.040-1.272
Q4	1.308	1.085-1.577	1.119	1.110-1.287

Note: Q: Quartile. CI: Confidence Interval. The contribution percentage of food groups was categorized into quartiles. Data are adjusted for sex, age, education level, and screen time.

A significant linear trend ($p_{trend}<0.02$) was observed for percentage contribution of ultra-processed foods and overweight and excess body fat.

DISCUSSION

Our results show that the intake of unprocessed or minimally processed foods is a protective factor for overweight and excess adiposity, whereas intake of ultra-processed foods is a risk factor for both conditions. These data are in agreement with previous studies showing that there is an association between ultra-processed food consumption and obesity [3-4,19-20]. The results also show that the consumption of minimally processed foods is inversely related to overweight [23,35]. The choice of foods, particularly with regard to their degree of processing, has an important influence on weight gain.

In modern society, ultra-processed foods have become widely available and are easy to purchase, which contributes to their high consumption. Their poor nutritional quality, high levels of sugars and fats, high palatability, large-sized portions (which affect eating behavior and self-control), and convenience may be associated with the increase in body weight among consumers [4,6,11,14]. However, the mechanisms that show the real interaction between the high consumption of ultra-processed products and diseases are still emerging [36].

A survey carried out in Latin America by the Pan American Health Organization between 2000 and 2013 showed a positive association between ultra-processed food sales and obesity in adults [37]. Canella *et al*. [6] analyzed food purchase data from the 2008-2009 Brazilian Consumer Expenditure Survey and identified a relationship between the purchase of high-energy, ultra-processed foods and overweight and obesity. Martins *et al*. [18], in a literature review, reported that the increase in ultra-processed food sales from 2000 to 2009 was closely associated with the increase in BMI in adults during the same period. These results indicate that the intake of highly processed foods may be related to an increase in obesity prevalence. Another important issue that must be emphasized is the high prevalence of physical inactivity evidenced in the Brazilian population, which is also associated with the increased consumption of snacks, sweetened drinks and fast food, the latter, strong predictors for obesity [38-40].

Research carried out in the United Kingdom with data from the National Diet and Nutrition Survey Program identified a linear trend between high consumption of ultra-processed foods and obesity and excess abdominal adiposity [41]. Hall *et al*. [42] compared healthy diets to diets rich in ultra-processed

foods and found that the latter promote weight gain and reduce satiety. The mechanisms underlying the relationship between high consumption of ultra-processed foods and obesity remain unclear. It is known that, because of their high energy density, sodium, saturated fat, and sugar contents, ultra-processed foods promote weight gain when consumed in large quantities [43]. Food additives, such as flavorings, colorings, emulsifiers, sweeteners, and thickeners, commonly found in ultra-processed foods, may also contribute to weight gain [21,44].

The high contribution of unprocessed or minimally processed foods to daily energy intake observed in the current study is in agreement with literature data [12,20,45,46]. Recent data from the Family Budget Survey carried out in Brazil also identified an important percentage calorie contribution, referring to the consumption of minimally processed foods [47]. Bielemann *et al*. [48] and Libanio *et al*. [49], however, found that ultra-processed foods were the major contributors to the energy intake of Brazilian individuals. Unprocessed or minimally processed foods are important sources of fiber, macronutrients, and micronutrients and, therefore, are an important part of a healthy diet.

Unprocessed or minimally processed foods were considered protective factors for obesity because of their low energy density, low sugar, total, saturated, and trans-fat contents, and high levels of protein and fiber [17]. In a clinical trial with Brazilian pregnant women, high consumption of minimally processed foods reduced the occurrence of obesity by 51% [35].

The daily energy intake of the study population was higher than that reported in other studies in Brazil [6,12,18,20]. High energy intake can lead to excessive weight gain, which may have contributed to the strong association between intake of ultra-processed foods and overweight.

A strong point of this study was the methodological precision of data collection. Information bias and application of a single 24-hour food recall may be considered limitations. It is possible that the amount of food intake was under- or overestimated. Nevertheless, several studies used a single 24-hour recall to evaluate nutrient intake [50,51]. Because of the cross-sectional nature of the current study, it is not possible to establish the temporality of associations, and the possibility of reverse causality cannot be excluded.

CONCLUSION

High consumption of ultra-processed foods is associated with overweight and excess adiposity, whereas intake of unprocessed or minimally processed foods is a protective factor for overweight. Nutrition education interventions aimed at overweight and obese adults should focus on the importance of reducing consumption of ultra-processed foods and increasing that of unprocessed and minimally processed foods.

CONTRIBUTORS

DCG SILVA, FG FERREIRA, and GZ LONGO colaborated with design and conception, and draw of the study, analysis and data interpretation, and review of the final version. DLM PEREIRA and ELG MAGALHÃES collaborated with conception and design of the study, analysis and data interpretation.

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