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ORIGINAL CONTRIBUTIONS

Absolute and Relative Changes in Ultra-processed Food Consumption and Dietary Antioxidants in Severely Obese Adults 3 Months After Roux-en-Y Gastric Bypass

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Abstract

Introduction Patients that undergo Roux-en-Y gastric bypass (RYGB) experience a dramatic change in food consumption; however, it is unknown whether food consumption changes in relation to the level of food processing.

Objective The aim of this work was to evaluate the relationship between ultra-processed food intake, dietary antioxidant capacity, and cardiometabolic risk factors in patients who underwent RYGB.

Methods This study included 58 obese patients who underwent RYGB bariatric surgery. Data collection was done pre-operatively and at 3 months post-surgery. The foods consumed were documented using a 3-day 24-h dietary recall, and food intake was classified based on NOVA and dietary total antioxidant capacity (TAC). Anthropometric and biochemical data as well as information on body composition were also collected. Metabolic syndrome (MS) was classified in accordance with the International Diabetes Federation.

Results Ultra-processed foods amounted to 27.2% and 19.7% of the total calories consumed during pre- and post-surgery periods, respectively. Regarding post-surgery, the caloric contribution of unprocessed or minimally processed foods increased, from 55.7 to 70.2% ($p = 0.000$). The TAC of foods consumed is inversely proportional to that of ultra-processed foods. Obvious changes were observed in all the anthropometric variables, lipid profile, glycemia, insulin resistance, and MS.

Conclusion Our results indicate that bariatric surgery is able to promote improvement in the diet quality of patients, reducing the consumption of ultra-processed foods and increasing the intake of unprocessed foods. The TAC of foods consumed is inversely proportional to that of ultra-processed ones.

Keywords NOVA · Ultra-processed foods · Antioxidants · Bariatric surgery

Introduction

Changes in global dietary patterns have caused a decline in fresh food consumption, in favor of ultra-processed foods, contributing to increased prevalence of obesity [1, 2]. Ultra-processed foods have contributed a 25 to 50% increase in the total daily caloric intake, per individual [3].

Ultra-processing is a method used to produce ready-to-eat, ready-to-drink, or ready-to-heat food products that can replace both unprocessed and minimally processed foods naturally ready for consumption, such as fruits, nuts, milk, water, beverages, desserts, and culinary dishes. Generally, ultra-processed foods are characterized by high energy density, excess total and saturated fats, high levels of sugar and sodium, and low fiber content. In addition, they are hyperpalatable, ready for consumption, and less perishable. Also, they are produced in mass and are more affordable than fresh or minimally processed foods [4].

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Studies report a rapid escalation in the intake of processed or ultra-processed foods and a decline in the consumption of unprocessed foods in several countries, including Brazil, Canada, the USA, and Australia [5–8]. Recent works have shown that ultra-processed food consumption is strongly related to drawbacks such as overweight/obesity [5], metabolic syndrome [9], and cancer [10]. Moreover, the higher caloric value of ultra-processed foods is closely associated with a higher total caloric intake, which in turn encourages weight gain [1].

It is interesting that no study has yet been done in patients with severe obesity who have undergone bariatric surgery in assessing their changes in food consumption in light of the NOVA classification. In clinical practice, these patients report changes in taste [11]; however, it is still unknown whether these changes exert any significant influence on the consumption of ultra-processed foods and antioxidants. Also, the impact of processed food consumption on patient evolution after surgery and cardiometabolic risk factors is still unknown.

Therefore, this study aimed to assess the relationship between the intake of ultra-processed foods, dietary antioxidant capacity, and cardiometabolic risk factors in patients who chose to undergo the Roux-en-Y gastric bypass (RYGB) bariatric surgery.

Methods

This prospective cohort study included 64 obese patients, adults of both sexes, and candidates for RYGB bariatric surgery. Prior to beginning the data collection, all the patients were requested to sign an informed consent form, accepting to participate in the study. The same interviewer gathered all the required data during individual nutritional care.

Food Consumption

The food consumption of the patients was evaluated based on a 3-day food record, being one of the days a weekend. During the interview, a photographic album was used to clearly define the portions [12]. Subsequently, the data were entered into the BRASIL NUTRI® Software designed for the 2008–2009 Family Budget Survey (POF, acronym in Portuguese) [13] conducted by the Brazilian Institute of Geography and Statistics—IBGE [14]; it presents a list of Brazilian foods and preparations with their nutritional composition.

The concept of ultra-processed food is included in the NOVA classification proposed by Monteiro in 2014 [4]. This classification consists of four distinct food groups, where the foods are categorized based on the degree and purpose of their processing, definition of the type of processing, and the underlying objective behind the same.

All foods reported by the patients were classified into four groups based on the NOVA food classification [6]: 1, unprocessed or minimally processed; 2, processed; 3, ultra-processed; 4, processed culinary ingredients. The aforementioned foods were further subdivided, depending on similarity in nutritional composition and extent of processing.

The average energy consumption (kcal) of the three R24h was calculated according to the level of food processing.

Anthropometry and Body Composition

Data on body weight (kg) were recorded using an electronic digital balance (Welmy®) of 300 kg capacity and accuracy of 100 g. Height (m) was measured with a stadiometer attached to a wall without skirting, in accordance with the recommendations of Jellife [15]. Thereafter, body mass index (BMI) was calculated and nutritional status was determined based on the WHO classification [16].

The variables, waist (WC) and neck (WN) circumference, were assessed using a 2-m long flexible and inelastic tape. WC was measured adopting the method of Calaway et al. [17] while the neck measurements were taken according to the technique adopted by Ben-Noun et al. [18].

Body composition was estimated employing a tetrapolar electrical bioimpedance analyzer (BIA), BIA 310 Biodynamics® Model, according to the manufacturer's protocol. Body fat (BF) was expressed as a percentage.

Markers of Cardiometabolic Risk

Using the enzymatic colorimetric test, the serum concentrations of glucose, triglycerides, total cholesterol, high-density lipoprotein cholesterol (HDL-c), and low-density lipoprotein cholesterol (LDL-c) were ascertained. Electrochemiluminescence immunoassay was used to determine serum insulin concentration. All these evaluations were accomplished in a third-party laboratory.

The degree of insulin resistance was established by the Homeostasis Model Assessment (HOMA-IR) [19]. The occurrence of metabolic syndrome (MS) was confirmed based on the protocol of the International Diabetes Federation [20].

Calculation of Dietary Total Antioxidant Capacity

To evaluate dietary total antioxidant capacity (TAC), a list of more than 3100 foods and preparations from several countries was used according to Carlsen et al. [21]. Thus, all the foods consumed by the patients were assigned antioxidant values expressed in mmol/100 g. The amount of TAC was the sum of the antioxidant capacity of each food/preparation consumed by the individual during the day, expressed in mmol/day and adjusted for caloric consumption, expressed in mmol/1000 cal.

Statistical Analysis

All the analyses were done using the STATA software version 13.0. The categorical variables were presented in absolute and relative values, and the numerical variables, in mean and standard deviation. Normality was verified by the Shapiro-Wilk test, histogram, and asymmetry coefficient. For non-normal variables, logarithmic conversion was done to promote asymmetry. For the normal variables, paired t test was performed and for the non-normal variables, the Wilcoxon test was performed. The Spearman correlation between TAC and food consumption according to the level of processing was also performed. A statistically significant association was considered for p value < 0.05.

Results

The study initially included 64 patients; however, due to the absence of patients during the appointments, it was possible to collect pre-operative food intake data of 58 patients and post-operative food intake data of 51 patients. The sample consisted of 70% women with a mean age of 39.34 ± 9.38, 62% with class III obesity (BMI > 40 kg/m^2), 41% were hypertensive and 30% were diabetic. In relation to post-surgery, a decline was noted in obesity, metabolic syndrome, insulin resistance, and cardiometabolic indicators (Table 1).

With respect to anthropometric data, all the variables analyzed presented a statistically significant decrease at 3 months after the RYGB surgery; the same was observed for glycemia, lipid profile, insulin, and HOMA-IR (Table 1).

In the pre-operative group, the caloric contribution of ultra-processed foods was 27.2%; however, in the post-operative group, it decreased to 19.7%. In this group, the foods that showed the greatest decline in intake generally included sweets, soft drinks, and snacks. The sole food group that revealed a rise in consumption was food supplements, as this patient group had been recommended to consume mainly protein [22]. However, the highest total daily caloric contribution, in the pre- and post-operative periods, 55.7% and 70.2%, respectively, was found to come from unprocessed or minimally processed foods. Among these, the most consumed pre- and post-surgery food group was meat, while the groups that showed the greatest increase in post-surgery intake included fruits, vegetables, and milk/derivatives (Table 2).

Regarding post-surgery, the total daily caloric intake decreased, as well as intake of unprocessed or minimally processed, processed, ultra-processed, and culinary ingredient groups (Table 2). TAC intake also decreased, although with no statistical significance (data not shown).

The correlation test revealed that TAC showed significance for total energy and processed foods during the pre-operative phase. In the post-operative stage, only the ultra-processed group presented a significant correlation. All these variables showed inverse and moderate correlation (Table 3).

Discussion

The observations of this study revealed that prior to the bariatric surgery, the caloric contribution of ultra-processed foods accounted for 27%; this value reduced to 19% after surgery.

Table 1 Characteristics of study participants pre-operative and 3-m post-operative RYGB

Variables	Before RYGB (n = 58)	After RYGB (n = 51)	p value*
Weight (kg)	117.1 ± 20.8	94.2 ± 13.7	0.000
WC (cm)	123.9 ± 14.3	106.9 ± 12.0	0.000
NC (cm)	41.9 ± 4.7	38.0 ± 3.5	0.000
BMI (kg/m^2)	42.5 ± 5.4	34.6 ± 4.5	0.000
Body fat (%)	42.6 ± 4.3	38.1 ± 5.4	0.000
Glucose (mg/dl)	101.9 ± 26.0	82.8 ± 8.5	0.000
TG (mg/dl)	142.7 ± 70.8	95.5 ± 31.7	0.000
LDL (mg/dl)	106.2 ± 27.6	93.8 ± 27.7	0.020
HDL (mg/dl)	47.6 ± 10.8	42.2 ± 10.3	0.005
Insulin (micro UI/mL)	15.7 ± 9.8	6.7 ± 3.4	0.000
HOMA-IR	3.9 ± 0.3	1.3 ± 0.1	0.000
Insulin resistance	28 (48.2%)	7 (13.7%)	0.000
Metabolic syndrome	41 (70.7%)	6 (11.8%)	0.000

Variables expressed as absolute and relative frequency, mean (±SD)

WC waist circumference, *NC* neck circumference, *BMI* body mass index, *BF* body fat, *TG* triglycerides, *CT* total cholesterol, *HOMA-IR* homeostasis model assessment index

**T*-paired test for the normal variables and Wilcoxon's test for the others. For categorical variables, the chi-square test was performed

Table 2 Caloric contribution of food groups consumed by patients before and after RYGB according to the level of food processing

Type of processing	Type of food	Before RYGB		After RYGB	
		Mean	%	Mean	%
Unprocessed or minimally processed foods	Fruit and fruit juice	191.96	8.7	174.38	16.8
	Vegetables	71.82	3.2	59.02	5.7
	Meat (beef, pork, chicken, fish, and eggs)	470.52	21.3	284.50	27.5
	Milk (fresh, whole, semi-skimmed, skimmed, powdered) and natural yoghurt	83.95	3.8	73.94	7.1
	Rice	155.71	7.0	43.34	4.2
	Beans	122.76	5.5	37.61	3.6
	Nuts	8.27	0.4	3.42	0.3
	Cereals: flour, popcorn, polenta, cooked corn meal, couscous, beiju, etc.	81.73	3.7	32.06	3.1
	Pasta: lasagna, pasta, pancake, pamonha	45.26	2.0	16.62	1.6
	Coffee and tea	1.21	0.05	1.16	0.1
Total (kcal)		1233.19*	55.7	726.05*	70.3
Processed foods	Bread (French bread, cheese bread, homemade cake, granola, etc.)	190.54	8.6	52.22	5.0
	Cheese	68.82	3.1	36.57	3.5
	Wine and beer	62.70	2.9	1.38	0.1
	Processed meat (bacon, beef and sardines) and canned vegetables	34.70	1.5	11.18	1.1
Total (kcal)		356.76*	16.1	101.35*	9.8
Ultra-processed foods	Sweets (gelatin, chocolate, fruit jam, lollipop, candy, etc.)	121.34	5.5	12.84	1.2
	Sugary drinks (soft drinks and artificial refreshments)	68.24	3.0	9.68	0.9
	Sausages (ham, mortadella, sausage, sausage, etc.) and chicken fingers	59.72	2.7	9.87	0.9
	Biscuits and breads	138.94	6.3	52.97	5.1
	Snacks, pizza, instant noodles, etc.	133.07	6.0	17.25	1.6
	Sweetened milk drink (yoghurts and flavored milks)	11.08	0.5	39.68	3.8
	Breakfast cereals, ready-made sauces (mayonnaise, ketchup) and curd	54.43	2.5	16.36	1.6
	Distilled drinks	16.72	0.7	–	–
	Supplements	–	–	45.98	4.4
Total (kcal)		603.54*	27.2	204.63*	19.7
Processed culinary ingredient (kcal)	Soy oil, olive oil, and sugar	21.08**	1.00	2.07**	0.2
Grand total		2214.57	100%	1034.10	100%

*$p < 0.000$; **$p < 0.036$

Table 3 Correlation between total dietary antioxidant capacity and the processing level of foods consumed by patients before and after RYGB

Variables	Before RYGB		After RYGB	
	r	*p* value*	*r*	*p* value*
Energy intake	− 0.45	0.000	− 0.22	0.111
Unprocessed or minimally processed foods	− 0.11	0.400	− 0.01	0.900
Processed foods	− 0.45	0.000	0.14	0.300
Ultra-processed foods	− 0.24	0.060	− 0.35	0.010
Processed culinary ingredient	− 0.10	0.410	− 0.15	0.291

*Spearman correlation

Several studies have, in the past, explored the caloric contribution of foods in the general population based on the degree of processing, but to date, no research has been conducted on obese patients who underwent bariatric surgery. To the best of our knowledge, this study is the first to examine the intake of ultra-processed foods before and after bariatric surgery.

The ingestion of ultra-processed foods is intimately related to obesity [23, 24], because of their nutritional profile, high in fats, sodium, and sugar, and extremely palatable, stimulating excessive intake. In fact, the convenience and purchasability of ultra-processed foods increase their attraction for consumption. Moreover, the increased consumption of ultra-processed foods can suppress the desire to eat unprocessed or minimally processed foods, rich in nutrient and fiber [4].

The present study revealed that the total energy value dropped by 53% in 3 months after surgery, corresponding to an average pre-operative and post-operative intake of 2235.6 kcal and 1037.6 kcal, respectively. A significant decline was observed in all the food groups according to degree of processing; however, in analyzing the percentage contribution of each group to total caloric value, it became clear that the unprocessed or minimally processed foods were the sole group that presented an upward trend from 55 to 70% at post-surgery. These changes were assumed to have occurred for several reasons, such as intolerance to foods rich in sugar and fats (usually ultra-processed foods), dumping syndrome, heightened patient awareness, and appropriate nutritional monitoring.

Furthermore, several investigations done on patients who underwent bariatric surgery reported alterations in taste perception and food preferences after the procedure [22, 25]. From a recent systematic review [11], it appeared that after RYGB surgery, sensitivity to sweet and fatty flavors increased, which reflected in a decrease in the desire for these foods; there also seemed to be a rise in the discrimination and identification of food odors. Such changes could encourage the maintenance of long-term weight loss.

According to the Swedish Obese Study (SOS) by Olbers et al. [26], alterations in food preferences of patients who underwent RYGB and vertical gastrectomy (VG) were noticeable 1 year after the surgery, for patients who underwent RYGB, a significant decline was noted in the consumption of foods like cookies, cakes, sweets, and desserts (ultra-processed), with a corresponding escalation in fruit and vegetable consumption. In another study involving RYGB patients, a significant rise was observed in the intake of protein-rich foods like chicken, fish, and eggs, as well as cooked vegetables, and a decrease in the consumption of sweet and fatty foods like chocolate, cakes, and biscuits [27].

Patients who undergo bariatric surgery are recommended to have a higher frequency of meals per day, but in smaller portion sizes and therefore, in general, fewer calories are consumed by the end of the day [28]. After bariatric surgery, the intake of high-energy (high-fat) foods is reduced, with a preference for low-density foods like fresh or minimally processed foods, such as fruits and vegetables [29]. The present study revealed an increased consumption of unprocessed or minimally processed foods, in both the pre- and post-operative groups. These findings concur with the results of Louzada et al. [23] and NOVA, in Brazil, in which a caloric contribution of 68.6% of this food group was reported in the adult and adolescent populations.

In addition to changes in dietary intake, the surgery induced significant alterations in body weight, body composition, and nutritional status within 3 months of the procedure. Similarly, the glycemic and lipid profiles also improved, accompanied by marked changes in insulin resistance (HOMA-IR). Changes in insulin sensitivity are linked to reduced caloric intake, loss of weight and body fat, and the release of hormones, such as GLP 1, which stimulates insulin production [30].

With reference to TAC, the pre-operative patients revealed that the higher the energy consumption, the lower the TAC, indicating that higher caloric intake is not always related to wiser food choices. Interestingly, the same outcome was not observed in the post-operative phase, where a negative correlation was evident between TAC and ultra-processed foods. The intake of dietary antioxidants is known to be linked to a decrease in cardiovascular risk factors, particularly due to the role they play in combating oxidative stress and inflammation [31, 32].

One of the limitations of this study is the post-surgery time, which was 3 months. However, we propose that it is not a source of bias, because studies have indicated that within a short post-surgery period, the food profile of patients (long term) can be tracked. In this case, at 3 months post-surgery, all patients are believed to have resumed their routines and eating normally. This study used a rigorous methodology, as the data were collected by a single interviewer, and the 3-day food recall employed was representative of the food habits of the patients.

Conclusion

RYGB had a significant impact on the reduction of ultra-processed food consumption and the increase in unprocessed or minimally processed food consumption after 3 months of surgery. This change was significant and suggests that RYGB surgery promotes a change in patients with obesity in relation to dietary habits. Dietary antioxidant capacity was not significantly altered after the surgery; however, a correlation with the consumption of ultra-processed foods was found, indicating that the higher the consumption of ultra-processed foods the lower the TAC. Therefore, long-term studies focused on food quality and level of processing should be performed in order to assess whether there is an association with post-operative evolution.

Authors' Contribution Sônia Lopes Pinto: contributed in the design of the study, data collection, analysis and interpretation, manuscript writing, and final version approval

Danielle Cristina Guimarães da Silva: contributed in the analysis and interpretation of the data, critical revision of the manuscript, and approval of the final version

Josefina Bressan: contributed in the design of the study, analysis and interpretation of the data, critical revision of the manuscript, and approval of the final version

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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