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Trabajo Original

Obesidad y síndrome metabólico

# Nutritional guidance, monitoring, and supplementation before and after bariatric surgery — Are we doing this correctly?

*Orientación, seguimiento y suplementación nutricional antes y después de la cirugía bariátrica: ¿lo estamos haciendo correctamente?*

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## Abstract

**Background and aims:** minimizing nutritional depletions after a Roux-en-Y gastric bypass (RYGB) may improve clinical results in the treatment of obesity. We evaluated nutritional aspects of obese women undergoing RYGB at a reference university hospital with a department specialized in bariatric surgery.

**Method:** based on the Dietary Reference Intakes developed by the Food and Nutrition Council, Institute of Medicine, and the guidelines issued by the American Society for Metabolic and Bariatric Surgery, we assessed the quantitative and qualitative adequacy of nutritional intake, supplementation, and biochemical monitoring of 20 women both before and 3 and 12 months after a RYGB. Data on nutritional intake was obtained by applying different food surveys, quantitatively interpreted by the Virtual Nutri Plus® software and using reference nutritional databases.

**Results:** nutritional intake deficits were already found before the RYGB ($p \leq 0.05$). These worsened postoperatively ($p \leq 0.05$), a period also marked by a qualitatively poor diet. The nutritional supplementation prescribed did not fully achieve the reference recommendations, and was poorly complied with by patients. Furthermore, nutritional monitoring was not carried out in all patients, recommended biochemical markers were not screened, and vitamin D depletions occurred.

**Conclusion:** our data suggest that institutions specialized in bariatric patient care may not be adequately adhering to well known guidelines, or applying efficient strategies to improve compliance.

**Keywords:**

Nutrition surveys. Nutritional status. Nutritional requirements. Nutrition assessment. Bariatric surgery. Gastric bypass.

## Resumen

**Antecedentes y objetivos:** minimizar el deterioro nutricional después del baipás gástrico en Y de Roux (BGYR) puede mejorar los resultados clínicos en el tratamiento de la obesidad. Se evaluaron aspectos nutricionales de mujeres obesas sometidas a BGYR en un hospital universitario de referencia con servicio especializado de cirugía bariátrica.

**Método:** con base en la Ingesta Dietética de Referencia desarrollada por el Consejo de Alimentos y Nutrición del Instituto de Medicina, y las directrices de la Sociedad Estadounidense de Cirugía Bariátrica y Metabólica, evaluamos la adecuación cuantitativa y cualitativa de la ingesta nutricional, la suplementación y el seguimiento bioquímico de 20 mujeres tanto antes como 3 y 12 meses después de un BGYR. Los datos de la ingesta nutricional se obtuvieron mediante la aplicación de diferentes encuestas alimentarias, interpretadas cuantitativamente por el software Virtual Nutri Plus® y utilizando bases de datos nutricionales de referencia.

**Resultados:** se encontraron déficits de ingesta nutricional antes del BGYR ($p < 0,05$). Estos empeoraron en el postoperatorio ($p < 0,05$), período también marcado por una mala alimentación cualitativa. La suplementación nutricional prescrita no cumplió plenamente con las recomendaciones de referencia y no fue bien cumplida por los pacientes. Además, la monitorización nutricional no se aplicó en todos los pacientes y no se examinaron todos los marcadores bioquímicos recomendados, hallándose depleciones de vitamina D.

**Conclusión:** nuestros datos sugieren que las instituciones especializadas en la atención de pacientes bariátricos podrían no estar siguiendo adecuadamente las pautas recomendadas, ni aplicando estrategias eficientes para mejorar su cumplimiento.

**Palabras clave:**

Encuestas de nutrición. Estados nutricionales. Requerimientos nutricionales. Evaluación nutricional. Cirugía bariátrica. Baipás gástrico.

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## INTRODUCTION

A high consumption of foods rich in energy density (mainly processed) and poor in protein, whole grains, and micronutrients may favor protein and micronutrient depletion in obese subjects (1,2). As part of the treatment of obesity, the Roux-en-Y gastric bypass (RYGB) is efficient in promoting significant and sustained weight loss along with metabolic benefits (i.e., diabetes remission), but being a restrictive and malabsorptive procedure it may worsen previous nutritional deficits and induce new ones (3,4). These deficits may range from 33 % to 40 % in the first year after surgery, and may contribute to the development of some debilitating organic disorders such as osteoporosis, Wernicke's encephalopathy, anemia, and peripheral neuropathy (5,6).

In this scenario, nutritional guidance and monitoring through multiple nutritional indicators are required for patients submitted to RYGB both before and after the procedure. Particularly, quantitative and qualitative data on food intake offer the main parameters on which to design dietary interventions, while reference guidelines can be applied for adequate nutritional supplementation and monitoring (7,8). When properly followed, these practices may help to achieve better clinical results in maintaining nutritional status and weight control after surgery (9,10).

The Bariatric and Metabolic Surgery Unit at the Digestive Surgery Department of a reference university hospital in the public health care system employs nutritional guidance and follow-up before and after RYGB. We assessed some dietetic and nutritional indicators in obese women treated at this institution in order to evaluate whether the dietary guiding and nutritional supplementation/monitoring offered were adequate in terms of adherence, sufficiency/insufficiency, and intervention period (pre- and post-operative). In parallel, by comparison with the reference tool "7-day food record" (7dR) we tested whether a 24-hour food recall (24hR) could adequately identify depletions in nutritional intake in this population, to allow an early design of proper dietary interventions.

## MATERIALS AND METHODS

### ETHICAL ISSUES AND SUBJECTS

The present investigation is part of the SURMetaGIT study (11), registered at www.clinicalTrials.gov (NCT01251016). Its specific protocol was approved by the local Ethics Committee (protocol nº 1011/19). After signing an informed consent form, 20 alphabetized adult women (18-60 years)who were obese (35-50 kg/m$^2$ of body mass index [BMI]) and candidates to RYGB were selected from February 2011 to December 2014. Exclusion criteria included refusal to participate in the study and participation in another interventional study protocol. All patients were submitted to a standardized RYGB without silicone ring and with standard biliopancreatic (50-60 cm) and feeding (100-120 cm) loop size, while routinely receiving dietary counseling along with the prescription of nutritional supplementation and monitoring before and after surgery. All the patients were assessed during the preoperative period and at 3 and 12 months after the RYGB for different nutritional indicators.

### ANALYSIS OF THE QUANTITATIVE AND QUALITATIVE ADEQUACY OF FOOD INTAKE

A quantitative food intake analysis was performed by using the reference method 7dR. In order to fill out the 7dR questionnaire each patient took home a Food Consumption Book - Visualizing Portions (12) after being properly instructed on how to select the photo number corresponding to the size of the portion ingested. During the recording week each patient received a telephone call to remind her to fulfill the food consumption book and to solve any possible doubts. In parallel, quantitative analyses of food intake were also carried out by applying a 24hR questionnaire. This was done to evaluate whether this simple tool, which offers immediate data on food intake, could perform similarly to the 7dR in the studied population. To answer the 24hR form the amount of food consumed was recorded in terms of units, home measurements, or through photos, during face-to-face interviews. The Virtual Nutri Plus® software (VNP) (13) was used to calculate total calories, macro and micronutrient intake, from the data obtained from both the 7dR and 24hR tools. The following data sources were used to estimate the nutritional composition of the ingested meals: Table of Chemical Composition of Food, developed by Sonia Tucunduva Philippi (14), and a local Table of Food Composition (TACO) (15). For the qualitative food intake assessment, a food frequency query (FFQ) including the most usual diets of our patients was applied. This included type, origin (i.e., natural or processed) and method used for cooking, milk and dairy products, animal proteins, oils, appetizers, cereals/legumes, fruits and vegetables, candy and desserts, drinks, and diet and light products (Table IV).

To verify the adequacy of the amount of nutrient intake in the pre- and post-operative periods from 7dR data we assessed compliance with the reference tables of the Dietary Reference Intake (DRIs) issued by the Food and Nutrition Council, Institute of Medicine(16) rather than prescribed energy and individual nutrient intakes. As protein intake, accordingly to the DRIs, is recommended in relation to body weight, this was calculated considering the mean weight of our patients for each period studied. To assess the adequacy of nutrient quality from FFQ data at the postoperative period, we verified compliance with the groups of foods recommended by the Nutritional Pyramid for Post-gastric Bypass Patients (17). Intake values up to 25 % above or below the recommended levels were considered adequate.

### ANALYSIS OF NUTRITIONAL SUPPLEMENTATION ADEQUACY AND ADHERENCE

The nutritional supplementation offered to the patients was analyzed in terms of: 1) Adequacy: we verified whether the sup-

plements prescribed by the Nutrition Service matched those recommended for bariatric patients by the American Society for Metabolic and Bariatric Surgery (ASBMS)(18). 2) Adhesion: we verified whether bariatric outpatients had taken the recommended supplementation by asking them about it from their first consultation — when the answer was yes, we recommended continuation; when the answer was not, we recommended to start taking the supplementation.

### ANALYSIS OF THE PERFORMANCE AND MONITORING OF NUTRITIONAL COUNSELING

To assess the performance of nutritional counseling whether the systemic levels of biochemical markers for protein and micronutrients were within the normal range was assessed. This evaluation was limited to the biochemical exams performed only by medical indication, which allowed us to identify the frequency of the nutritional and blood chemistry monitoring applied.

### SAMPLE SIZE AND STATISTICAL ANALYSIS

A sample of 20 participants was considered adequate to obtain representative data and a comparison of two food consumption assessment tools (24hR and 7dR), with a power of 80 % calculated based on the number of nutrient measurements and the number of instruments through a non-parametric ANOVA test, under a 0.05 alpha value. Descriptive data and continuous variables were expressed in terms of mean and standard deviation or median and minimum-maximum values. For the comparative analysis of data we used Student's t-test and paired Mann-Whitney test when appropriate, with a confidence level of 95 %. All analyses and graphs were carried out using the R program (version 3.4.1).

## RESULTS

### DESCRIPTIVE PATIENT DATA

Patients had a mean age of 48.7 ± 7.0 years, and their descriptive characterization is shown in table I. All patients experienced a decrease in body measurements and weight loss after their RYGB.

**Table I.** Descriptive characteristics of the obese patients submitted to Roux-en-Y gastric bypass

| Variable | Factor | Value |
|---|---|---|
| Ethnicity (%) | Brown | 25.0 |
| | Black | 15.0 |
| | White | 60.0 |
| Scholarity (%) | Incomplete elementary school | 15.0 |
| | Elementary school | 25.0 |
| | High school | 35.0 |
| | Incomplete graduation | 5.0 |
| | Graduation | 20.0 |
| Weight (kg) | Preoperative | 114.5 ± 15.9 |
| | Postoperative, 3 months | 94.2 ± 13.8 |
| | Postoperative, 12 months | 80.1 ± 11.5 |
| Body mass index (kg/m$^2$) | Preoperative | 46.4 ± 5.4 |
| | Postoperative, 3 months | 37.9 ± 4.2 |
| | Postoperative, 12 months | 32.5 ± 3.7 |
| Waist/Hip ratio (cm) | Preoperative | 138.5 ± 12.3 |
| | Postoperative, 3 months | 123.1 ± 11.6 |
| | Postoperative, 12 months | 112.2 ± 9.9 |

### PRE- AND POST-OPERATIVE QUANTITATIVE ASSESSMENT OF NUTRITIONAL INTAKE

The quantitative data on food intake obtained with the 7dR are described in table V (calories and macronutrients) and table VI (vitamins and minerals). There was a significant reduction in the consumption of calories, macronutrients, and micronutrients (except vitamins B12, C and D, and calcium) per day at 3 and 12 months after RYGB, as compared to the preoperative period. A lower intake of polyunsaturated fat and a higher intake of carbohydrates were observed at the 12-month postoperative cutoff, in comparison to the 3-month postoperative cutoff. No significant differences were observed in the data between the 24hR and 7DR tools regarding the intake of energy, macronutrients, and micronutrients indicated for supplementation in RYGB patients (vitamin B12, folate, iron, zinc, and calcium) ($p > 0.05$) (Fig. 1). Nevertheless, at the 12-month postoperative cutoff the 24hR tool did not identify the increase in carbohydrate intake identified by the 7dR (versus at 3 months postoperative), and highlighted a deficit in vitamin D and calcium intake (versus at 3 months postoperative) not identified by the reference tool 7dR.

As shown in table II, according to the DRI recommendations, excessive carbohydrate and deficient protein and fiber intakes were observed preoperatively. The consumption of carbohydrates and proteins was slightly below and above these recommendations at 3 and 12 months after surgery, respectively, whereas the deficiency in total fiber consumption was aggravated by surgery in both the short (3 months) and long term (12 months). Inadequate preoperative consumption of micronutrients included a mild insufficiency of vitamins B2 and B6, phosphorus, selenium, and zinc; a relevant deficiency in the ingestion of vitamins B5, D and E, folate, calcium, magnesium, and potassium; and an elevated consumption of sodium. All inadequacies in micronutrient consumption worsened postoperatively, except for vitamin D and iodine (whose intakes showed a slight increase in the postoperative period at 3 months) and sodium (whose intake decreased slightly in the two post-operative time points evaluated);

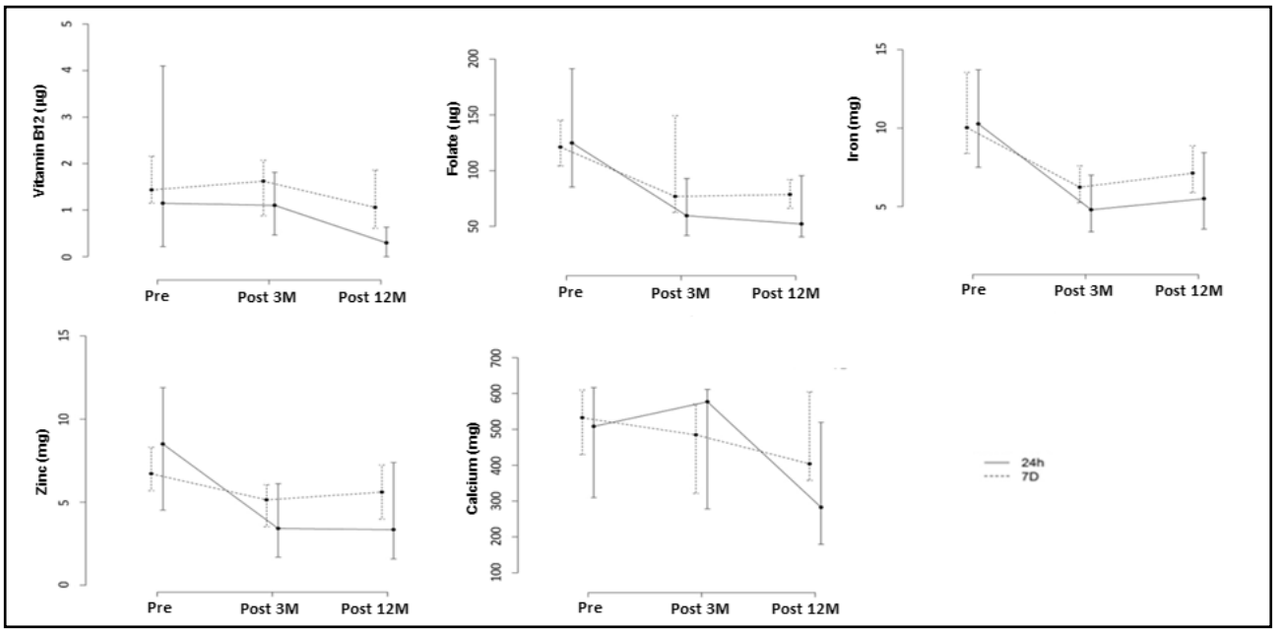


**Figure 1.**

Ingestion of micronutrients by obese patients before and at 3 and 12 months after a Roux-en-Y gastric bypass, according to a 7-day food registry and 24-hour food recall. Data are expressed as median ingestion per period (pre- and 3 and 12 post-operative months). Pre: preoperative; Post 3M: at 3 months postoperative; Post 12M: at 12 months postoperative; 24h: 24-hour food recall; 7D: 7-day food record.

**Table II.** Adequacy of nutrient intake by obese patients before and 3 and 12 months after a Roux-en-Y gastric bypass, according to the Dietary Reference Intakes (DRIs)

| Nutrient | DRIs | Preoperative | Postoperative | |
|---|---|---|---|---|
| | | | 3 months | 12 months |
| Protein (g/kg) | 0.8 | **0.6 ± 0.9** | **0.5 ± 1.1** | **0.7 ± 1.6** |
| Carbohydrates (g) | 130.0 | *208.8 ± 47.3* | *112.8 ± 34.0* | *140.2 ± 49.7* |
| Total fiber (g) | 25.0 | **15.0 ± 5.6** | **9.7 ± 3.9** | **10.0 ± 3.3** |
| Vitamin A (µg) | 700.0 | *737.8 ± 693.6* | *700.9 ± 637.1* | *772.8 ± 874.4* |
| Vitamin B1 (mg) | 1.1 | *1.6 ± 1.2* | **1.0 ± 0.6** | **0.9 ± 0.3** |
| Vitamin B2 (mg) | 1.1 | **0.9 ± 0.3** | **0.7 ± 0.4** | **0.6 ± 0.4** |
| Vitamin B3 (mg) | 14.0 | *16.8 ± 5.5* | **10.4 ± 4.1** | **11.6 ± 5.5** |
| Vitamin B5 (mg) | 5.0 | **2.0 ± 0.5** | **1.5 ± 0.6** | **1.4 ± 0.6** |
| Vitamin B6 (mg) | 1.3 | **1.0 ± 0.3** | **0.7 ± 0.2** | **0.8 ± 0.23** |
| Vitamin B12 (µg) | 2.4 | *3.3 ± 4.7* | **1.45 ± 0.8** | **1.3 ± 0.8** |
| Vitamin C (mg) | 75.0 | *359.3 ± 799.2* | *136.4 ± 113.57* | *107.1 ± 71.5* |
| Vitamin D (µg) | 5.0 | **1.6 ± 4.1** | **3.4 ± 12.7** | **0.3 ± 0.2** |
| Vitamin E (mg) | 15.0 | **9.6 ± 3.0** | **6.4 ± 1.8** | **6.4 ± 1.6** |
| Calcium (mg) | 1000.0 | **517.9 ± 135.7** | **477.2 ± 204.9** | **460.7 ± 215.9** |
| Copper (mg) | 0.9 | *3.8 ± 13.3* | **0.7 ± 0.3** | **0.7 ± 0.5** |
| Folate (µg) | 400.0 | **127.8 ± 32.6** | **95.0 ± 52.0** | **88.5 ± 47.0** |
| Iron (mg) | 18.0 | *38.6 ± 81.8* | **9.1 ± 12.5** | **8.7 ± 5.0** |
| Phosphorus (mg) | 700.0 | **658.9 ± 184.7** | **461.2 ± 156.2** | **488.0 ± 142.6** |
| Magnesium (mg) | 320.0 | **150.4 ± 33.2** | **104.7 ± 27.6** | **112.4 ± 33.3** |
| Manganese (mg) | 1.8 | *2.1 ± 3.5* | *2.06 ± 5.21* | **1.0 ± 0.3** |
| Potassium (mg) | 4700.0 | **1719.1 ± 375.8** | **1341.1 ± 411.2** | **1313.8 ± 432.1** |
| Selenium (µg) | 55.0 | **47.5 ± 10.5** | **26.5 ± 12.7** | **27.9 ± 17.6** |
| Sodium (mg) | *1300.0* | *3534.2 ± 804.2* | *2731.4 ± 556.4* | *2444.2 ± 422.7* |
| Zinc (mg) | 8.0 | **7.1 ± 2.3** | **4.8 ± 1.9** | **5.6 ± 2.2** |

*Data on consumption expressed as mean ± standard deviation. Values highlighted in bold and italics indicate intake below and above DRI recommendations, respectively.*

**Table III.** Adequacy of daily micronutrient supplementation prescribed for obese patients submitted to Roux-en-Y gastric bypass, according to the recommendations of the American Society for Metabolic and Bariatric Surgery (ASMBS)

| Micronutrient | ASMBS Recommendation | Service supplementation |
|---|---|---|
| Vitamin A | 5,000-10,000 IU/day | 16,000 IU/day |
| Vitamin B1 | **≥ 12 mg/day** | **3 mg/day** |
| Vitamin B12 | 350-500 µg/day | 500-1,000 µg/month |
| Vitamin D | 3,000 IU/day | 4,400 IU/day |
| Vitamin E | **15 mg/day** | **0** |
| Vitamin K | **90-120 µg/day** | **0** |
| Calcium | 1,200-1,500 mg/day | 1,200 mg/day |
| Copper | **2 mg/day** | **0** |
| Iron | 45-60 mg/day | 40-80 mg/day |
| Folate | **400-800 µg/day** | **0** |
| Zinc | **8-22 mg/day** | **0** |

*Values highlighted in bold indicate intake below ASMBS recommendations.*

however, these micronutrients continued to be consumed in inadequate amounts as compared to DRIs. Some inadequacies in micronutrient consumption were exclusive to the postoperative period, including those of vitamins B3 and B12, iron, and copper in both postoperative time points, and of manganese at 12 months after surgery.

## POSTOPERATIVE QUALITATIVE ASSESSMENT OF NUTRITIONAL INTAKE

There was a decrease in the consumption frequency of the most important protein sources reported by our patients at 12 months after RYGB, including chicken meat, solid fresh cheese, skimmed or semi-skimmed milk, and legumes, in relation to the postoperative 3-month cutoff. The exception in this food group occurred for beef, whose intake remained similar at 3 and 12 months postoperatively. There was also an increase in the consumption of tubers, white rice, pasta, bread, and biscuits at 12 months after surgery as compared to the 3-month postoperative cutoff. In parallel, no changes were observed in the intake of raw and cooked vegetables and fruit with low sugar content.

According to the food pyramid recommended by the ASMBS, the intake of protein-rich foods, and of raw and cooked vegetables and fruits with low sugar contents was deficient at the post-operative time points studied. Tubers were not consumed or were below the recommended amount, regardless of the small increase in the amount ingested at 12 months after surgery. The specific analysis of the food groups whose ingestion the ASMBS advised against showed that at the 3-month postoperative cutoff half of the patients consumed sausages (sausage, salami, ham, and mortadella) and 40 % consumed sandwiches, pizza, sfiha, snacks, cheetos, and fasts-foods at least once a week, whereas at the 12-month postoperative time point the consumption frequency of these foods had not changed but the number of patients consuming them increased. The consumption frequencies of margarine and diet soft drinks were high in the postoperative period after 3 months (2-4 times per week). In the 12-month postoperative cutoff only the frequency of diet soft drink consumption decreased, but the number of patients consuming both these foods increased.

## ADEQUACY OF NUTRITIONAL SUPPLEMENTATION

In addition to the recommendation for supplementary protein ingestion, the patients who underwent RYGB in the present study had prescriptions for a multivitamin supplement (in drops) provided by the institution (116,667 IU of vitamin A; 0.1 mg of vitamin B1; 0.067 mg of vitamin B2; 0.467 mg of vitamin B3; 1,667 mg of vitamin C; 30 IU of vitamin D), as well as for supplementation with vitamin D and vitamin A (3,000 IU/day and 16,000 IU/day, respectively, in drops), vitamin D (4,400 in tablets), vitamin B12 (500-1,000 µg/month in injections), iron (40-80 mg/day in tablets), and calcium (1,200 mg/day in tablets) to be purchased by the patients themselves with their own resources. The total sum of these supplements provided adequate amounts of calcium and iron, higher amounts of vitamins A, D, and B12, and insufficient vitamin B1, according to the ASMBS recommendations (Table III). These supplements did not include vitamins E and K, copper, folate, and zinc (also recommended by the ASMBS), whose supplementation was prescribed only occasionally, and at the discretion of the physician in charge. Of the study patients, in the postoperative period one received a specific prescription of zinc (tablets), two of folic acid (tablets), and one of protein (albumin or whey protein), whereas no prescriptions were issued for vitamins E and K in any of them.

## ADHERENCE TO NUTRITIONAL SUPPLEMENTATION

The supplements prescribed in both postoperative periods were only partially taken by the patients. Supplement compliance at 3 months postoperatively was 100 % for multivitamin HC; 40 % for vitamin D and vitamin A; 75 % for vitamin B12; 10 % for folic acid; 85 % for iron; 40 % for albumin; 0 % for zinc; 20 % for calcium; and 5 % for protein. Supplement compliance at 12 months postoperatively was 90 % for multivitamin HC; 45 % for vitamin D and vitamin A; 20 % forvitamin B12; 75 % for folic acid; 80 % for iron; 10 % for albumin; 5 % for zinc; 25 % for calcium; and 0 % for protein.

**Table IV.** Food frequency query administered to obese patients 3 and 12 months after a Roux-en-Y gastric bypass

| Food | Portion (n°/description) | Frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/day | ≥ 2/ day | 5-6/ week | 2-4/ week | 1/ week | 1-3/ week | R/N | Amount (g/mL) |
| Skimmed milk | | | | | | | | | |
| Semi-skimmed milk | | | | | | | | | |
| Whole milk | | | | | | | | | |
| Yogurt | | | | | | | | | |
| White cheese (mines/frescal) | | | | | | | | | |
| Yellow cheese (dish/mozzarella) | | | | | | | | | |
| Creamy cheese | | | | | | | | | |
| Fried/scrambled egg | | | | | | | | | |
| Boiled egg | | | | | | | | | |
| Beef meat | | | | | | | | | |
| Pork meat | | | | | | | | | |
| Chicken | | | | | | | | | |
| Fresh fish | | | | | | | | | |
| Canned fish (sardines, tuna) | | | | | | | | | |
| Sausages (sausage, salami, ham, mortadella) | | | | | | | | | |
| Meat preserved in salt (cod, dried meat, feijoada ingredients) | | | | | | | | | |
| Viscera (liver, kidney, heart) | | | | | | | | | |
| Olive oil | | | | | | | | | |
| Salad dressing | | | | | | | | | |
| Bacon | | | | | | | | | |
| Butter | | | | | | | | | |
| Margarine | | | | | | | | | |
| Mayonnaise | | | | | | | | | |
| Snacks (crisps, cheese, peanuts) | | | | | | | | | |
| Sandwiches | | | | | | | | | |
| Pizza | | | | | | | | | |
| Sfiha | | | | | | | | | |
| Canned food (corn, peas, palm hearts, olives) | | | | | | | | | |
| Brown rice | | | | | | | | | |
| Polished rice | | | | | | | | | |
| Whole grain bread | | | | | | | | | |
| French bread | | | | | | | | | |
| Salty crackers | | | | | | | | | |
| Sweet cookies | | | | | | | | | |
| Cakes | | | | | | | | | |
| Spaghetti | | | | | | | | | |
| Beans | | | | | | | | | |
| Raw leaf | | | | | | | | | |
| Sautéed/cooked | | | | | | | | | |

*(Continuation in the next page)*

**Table IV (Cont.).** Food frequency query administered to obese patients 3 and 12 months after a Roux-en-Y gastric bypass

| Food | Portion (n°/description) | Frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/day | ≥ 2/ day | 5-6/ week | 2-4/ week | 1/ week | 1-3/ week | R/N | Amount (g/mL) |
| Raw vegetables | | | | | | | | | |
| Cooked vegetables | | | | | | | | | |
| Tubers (manioc, potatoes, yams) | | | | | | | | | |
| Fruits | | | | | | | | | |
| Ice cream | | | | | | | | | |
| Pies | | | | | | | | | |
| Jelly | | | | | | | | | |
| Candy | | | | | | | | | |
| Chocolates | | | | | | | | | |
| Coffee with sugar | | | | | | | | | |
| Coffee without sugar | | | | | | | | | |
| Natural juice with sugar | | | | | | | | | |
| Natural juice without sugar | | | | | | | | | |
| Artificial juice with sugar | | | | | | | | | |
| Artificial juice without sugar | | | | | | | | | |
| Soda | | | | | | | | | |
| Sweeteners | | | | | | | | | |
| Margarine | | | | | | | | | |
| Cottage cheese/yogurt | | | | | | | | | |
| Soft drinks (light) | | | | | | | | | |

## PERFORMANCE/MONITORING OF NUTRITIONAL SUPPLEMENTATION

Patients frequently presented normal values for biochemical markers of protein and micronutrients at all study time points. The exception was lower levels of vitamin D in the preoperative period (17 [9-27]) as compared to the reference value (30-100), which almost normalized during the postoperative period at 3 (26 [15-45]) and 12 months (26 [21-32]). Borderline hemoglobin and protein values were found in all of the study cutoff time points but remained within the normal range. However, the monitoring of nutritional blood chemistry markers was poor in frequency and comprehensiveness, only partially meeting ASMBS recommendations. No requests for vitamin A, B1, K, and E testing were found for any of the patients studied at any of the evaluated periods, nor for zinc (at 3 months) and copper (at 3 and 12 months) during the postoperative period. In addition, the evaluated markers were not assessed in the total patient population.

## DISCUSSION

A marked decrease in macronutrient intake is largely reported after bariatric procedures, so that food intake may result in a deficiency > 50 % in nutritional needs in some patients (19,20). In particular, protein consumption may fall dramatically and become insufficient, possibly due to intolerance of protein sources, mainly of meat (5,21-23). Accordingly, our sample of patients submitted to RYGB exhibited a deficiency in protein intake (mean, 50 g/day), but this did not worsen in the long term, and they tolerated eating meat. When comparing the 3- and 12-month postoperative cutoffs, we found significant changes only in the consumption of carbohydrates (increased) and polyunsaturated fats (decreased). These changes occurred in parallel to a high intake of industrialized foods and a consequent decrease in the use of polyunsaturated fats for food cooking. An insufficient consumption of total fiber was also observed by us, and is consistent with the higher intake of refined and industrialized carbohydrates. Since the amount and quality of the carbohydrates ingested during the postoperative period of bariatric surgery may result in reduced weight loss (24), our data suggest the relevance of controlling carbohydrate intake in patients having undergone a RYGB, and highlight the difficulties involved in achieving this aim, even under nutritional counseling.

Depletion of micronutrients is also widely reported in bariatric patients even before surgery (7,25,26). Accordingly, deficits in micronutrient intake were largely observed by us before the RYGB, although some of these occurred only postoperatively. Actual-

**Table V.** Ingestion of calories and macronutrients by obese patients before and 3 and 12 months after a Roux-en-Y gastric bypass, according to a 7-day food registry

| Variable | Preoperative | Postoperative, 3 m | Postoperative, 12 m | p-value (1) | p-value (2) | p-value (3) |
|---|---|---|---|---|---|---|
| Calories (kcal) | 1677.6<br>972.3-2625.0 | 1004.2<br>514.9-1382.8 | 985.2<br>748.7-1864.9 | *< 0.001* | *< 0.001* | 0.07 |
| Proteins (g) | 71.4<br>43.0-89.8 | 47.7<br>22.5-82.7 | 57.3<br>24.1-86.2 | *< 0.001* | *0.007* | 0.128 |
| Carbohydrates (g) | 203.3<br>120.1-348.5 | 108.5<br>65.7-193.9 | 129.8<br>64.8-264.1 | *< 0.001* | *< 0.001* | *0.037* |
| Total fibers (g) | 13.8<br>6.5-31.1 | 9.4<br>4.1-17.7 | 9.7<br>4.4-15.4 | *0.001* | *0.002* | 0.783 |
| Insoluble fibers (g) | 3.4<br>1.4-6.3 | 2.3<br>0.9-4.2 | 2.5<br>0.7-4.5 | *0.02* | *0.004* | 0.6 |
| Soluble fibers (g) | 1.89<br>0.6-3.6 | 1.1<br>0.6-3.2 | 1.5<br>0.2-3.3 | *0.019* | *0.012* | 0.388 |
| Total fat (g) | 62.2<br>34.8-99.5 | 38.8<br>19.1-52.9 | 37.9<br>26.5-53.6 | *< 0.001* | *< 0.001* | 0.886 |
| Saturated fat (g) | 15.7<br>98.1-28.2) | 8.9<br>5.2-17.3 | 9.7<br>5.1-16.4 | *< 0.001* | *< 0.001* | 0.841 |
| Monounsaturated fat (g) | 16.52<br>8.2-26.3 | 12.0<br>4.7-17.2 | 11.4<br>7.3-17.7 | *< 0.001* | *0.002* | 0.654 |
| Polyunsaturated fat (g) | 12.1<br>6.5-18.3 | 8.5<br>5.7-10.3 | 6.3<br>3.8-8.9 | *< 0.001* | *< 0.001* | *< 0.001* |
| Cholesterol (mg) | 194.1<br>62.3-343.7 | 125.5<br>52.4-334.2 | 136.2<br>59.9-331.4 | *0.007* | *0.004* | 0.784 |

*p-value (1): at 3 months postoperative* vs. *preoperative; p-value (2): at 12 months postoperative* vs. *preoperative; p-value (3): at 12 months postoperative* vs. *3 months postoperative. Results obtained using Student's t-test and Mann-Whitney paired test, expressed as median and minimum-maximum ingestion values for the period. Italic values indicate a significant statistical difference ($p \leq 0.05$).*

ly, we found depletions of all the assessed micronutrients early (3 months) after surgery except for vitamins C and A, and sodium. Deficits in micronutrient intake may negatively impact several physiological functions, and increase the risk of comorbidities, as well as affect the metabolism of leptin and insulin (27).

A qualitative improvement in food ingestion should compensate for the small portion of diet actually eaten, but this goal seems difficult to achieve. A low consumption of food sources of proteins, fruits, vegetables, and vegetable oils, and a high consumption of carbohydrates, sugars, and fats are reported in this population (28). Indeed, the postoperative intake of foods to be avoided, as recommended by the ASMBS, remained high in our study. This finding suggests that, despite receiving nutritional counseling, our patients exhibited quantitative but not qualitative dietary changes, which may result in relevant nutritional deficiencies.

Nutritional guidance seeking to promote the quality of food intake and to include micronutrient supplementation after bariatric surgery is fundamental to avoid the potential nutritional deficiencies to which bariatric patients are most susceptible (29). The patients who took part in this study were advised to prioritize protein-rich foods and to avoid caloric and/or highly processed foods with low nutritional quality for consumption, along with the intake of specific vitamin-mineral supplements. However, adherence to these recommendations was low, and the quality of the nutritional supplementation that was recommended did not fully comply with the ASMBS recommendations (18). In addition, we also found inadequacies in nutritional biochemical monitoring, even considering that not all patients included the study were examined for serum levels of nutritional markers, and some of the markers recommended by the ASMBS (18) were not measured in the patients examined.

There is no specific strategy to correct the inadequacies pointed out in our study concerning the nutritional care of patients submitted to RYGB. Nevertheless, such strategies may include actions to promote patient education regarding the nutritional and clinical consequences of their surgery. Educational actions should start already during the preoperative period, since orientations to promote meal fractioning, increase intake of high nutritional value foods, and decrease high-calorie foods have been shown their ability to modify the dietary patterns of pre-bariatric patients (30). Particularly, in our study, the application of a 24hR questionnaire provided data on nutritional intake quite similar to those provided by the 7dR. Our findings shed some light on the possibility of obtaining representative data on the eating habits of patients submitted to RYGB from the first visit, thus allowing early, personalized nutritional counseling.

**Table VI.** Ingestion of micronutrients by obese patients before and 3 and 12 months after a Roux-en-Y gastric bypass, according to a 7-day food registry

| Variable | Preoperative | Postoperative, 3 m | Postoperative, 12 m | p-value (1) | p-value (2) | p-value (3) |
|---|---|---|---|---|---|---|
| Vitamin A (mg) | 461.4<br>153.7-2655.6 | 500.8<br>63.0-2358.1 | 660.9<br>28.0-4143.2 | 0.596 | 0.756 | 0.622 |
| Vitamin B1 (mg) | 1.4<br>0.8-6.6 | 0.8<br>0.34-2.5 | 0.8<br>0.4-1.7 | *0.007* | *< 0.001* | 0.701 |
| Vitamin B2 (mg) | 0.8<br>0.5-1.6 | 0.6<br>0.2-1.6 | 0.6<br>0.3-2.0 | *0.03* | *< 0.001* | 0.784 |
| Vitamin B3 (mg) | 15.2<br>7.4-28.1 | 10.1<br>4.5-22.3 | 10.7<br>4.7-29.5 | *< 0.001* | *0.002* | 0.729 |
| Vitamin B5 (mg) | 1.97<br>1.0-2.9 | 1.5<br>0.6-2.9 | 1.3<br>0.6-3.7 | *0.010* | *< 0.001* | 0.189 |
| Vitamin B6 (mg) | 1.0<br>0.5-1.6 | 0.7<br>0.3-1.2 | 0.9<br>0.2-1.3 | *0.010* | *0.014* | 0.261 |
| Vitamin B9 (mg) | 121.0<br>89.1-200.4 | 76.9<br>1.5-195.1 | 78.5<br>30.3-237.9 | *0.021* | *0.001* | 0.571 |
| Vitamin B12 (mg) | 1.2<br>0.6-16.9 | 1.84<br>0.2-22.3 | 1.1<br>0.5-41.7 | 0.729 | 0.070 | 0.294 |
| Vitamin C (mg) | 110.7<br>25.8-3575.7 | 105.1<br>22.1-448.2 | 94.9<br>5.4-290.3 | 0.409 | 0.097 | 0.522 |
| Vitamin D (mg) | 0.7<br>0.1-19.1 | 0.3<br>0.1-57.5 | 0.3<br>0.1-0.7 | 0.231 | *0.001* | 0.064 |
| Vitamin E (mg) | 9.0<br>4.7-15.9 | 6.7<br>3.2-9.5 | 6.6<br>3.7-9.3 | *0.001* | *< 0.001* | 0.959 |
| Calcium (mg) | 532.4<br>311.9-843.1 | 484.7<br>106.6-993.0 | 403.9<br>92.9-806.4 | 0.375 | 0.177 | 0.717 |
| Copper (mg) | 0.8<br>0.5-60.5 | 0.5<br>0.2-1.3 | 0.6<br>0.2-2.5 | *< 0.001* | *0.004* | 0.312 |
| Iron (mg) | 10.0<br>6.8-344.8 | 6.2<br>2.7-60.7 | 7.1<br>3.6-24.2 | *0.001* | *< 0.001* | 0.165 |
| Phosphorus (mg) | 584.5<br>428.5-1001.1 | 460.0<br>186.3-834.3 | 520.6<br>180.5-763.9 | *< 0.001* | *< 0.001* | 0.41 |
| Iodine (mg) | 7.6<br>2.3-47.3 | 17.0<br>2.5-51.2 | 5.9<br>0.9-39.1 | *0.021* | 0.165 | *< 0.001* |
| Magnesium (mg) | 143.8<br>85.3-209.6 | 109.6<br>54.7-165.8 | 115.4<br>46.8-164.9 | *< 0.001* | *< 0.001* | 0.349 |
| Manganese (mg) | 1.2<br>0.7-16.9 | 0.8<br>0.5-24.1 | 0.9<br>0.5-1.9 | *< 0.001* | *0.003* | 0.409 |
| Potassium (g) | 1733.3<br>838.6-2276.9 | 1330.9<br>630.5-2276.9 | 1408.7<br>392.5-1984.2 | *< 0.001* | *0.001* | 0.956 |
| Selenium (mg) | 47.6<br>28.0-62.5 | 21.9<br>7.7-47.3 | 25.4<br>2.6-86.0 | *< 0.001* | *< 0.001* | 0.812 |
| Sodium (g) | 3412.4<br>2300.4-5942.7 | 2648.4<br>1795.7-3977.3 | 2371.0<br>1733.0-3528.6 | *< 0.001* | *< 0.001* | *0.027* |
| Zinc (mg) | 6.7<br>2.5-12.4 | 5.1<br>1.4-7.7 | 5.6<br>1.9-9.7 | *0.002* | *0.040* | 0.202 |

*p-value (1): at 3 months postoperative* vs. *preoperative; p-value (2): at 12 months postoperative* vs. *preoperative; p-value (3): at 12 months postoperative* vs. *3 months postoperative. Results obtained using Student's t-test and Mann-Whitney paired test, expressed as median and minimum-maximum ingestion values for the period. Italic values indicate a significant statistical difference ($p \leq 0.05$).*

Our study presents some limitations that deserve to be highlighted. We analyzed a small sample made up only of women, but its size had a power of 80 % power to answer the scientific questions investigated, and the inclusion of only women by rigid selection criteria made the population homogeneous for analysis. In addition, the biochemical data analyzed were restricted to specific tests requested by physicians. Consequently, there is a shortage of these analyses, which may account for the fact that we did not find any biochemical changes in nutritional markers that were consistent with the non-conformities identified in quantitative and qualitative nutritional intake. On the other hand, this approach allowed us to identify a quantitative and qualitative deficiency of requests for blood chemistry tests capable of reflecting debilitated nutritional states in the bariatric patients who were cared for in the study's institution.

In summary, despite receiving routine dietary guidance, our patients undergoing RYGB presented quantitative and qualitative deficiencies in nutritional intake, which may compromise clinical results. Furthermore, the nutritional supplementation and monitoring that was put in place exhibited a poor compliance with well known guidelines, and/or was poorly adhered to by patients, suggesting that institutions specialized in bariatric care may be neither adequately updating these procedures, nor applying efficient strategies to improve compliance.

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