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Obesity coexists with malnutrition? adequacy of food consumption by severely obese patients to dietary reference intake recommendations

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Abstract

To assess the adequacy of food intake in severely obese patients and describe their main nutritional deficiencies on the basis of Dietary Reference Intakes (DRIs). Patients on a waiting list for bariatric surgery were sequentially recruited from March 2010 to November 2011. All subjects underwent nutritional status assessment (anthropometry, dietary recall and semi-structured interview), socioeconomic evaluation (Brazilian Association of Research Companies criteria) and laboratory testing (glucose/hormone/lipid panel). A total of 77 patients were assessed, 50 of whom (76.6%) were female. Mean age was 44.48±12.55 years. The most common comorbidities were hypertension (72.4%), binge eating disorder (47.4%), type 2 diabetes mellitus (32.9%), sleep apnea (30.3%) and dyslipidemia (18.4%). Macronutrient intake was largely adequate, in view of the high calorie intake. However, some micronutrient deficiencies were present. Only 19.5% of patients had an adequate intake of potassium, 26.0% of calcium, and 66.2% of iron. All subjects consumed more than the minimum recommended intake of sodium, with 98.7% reaching the upper limit. B-complex vitamin intake was satisfactory (adequate in >80% of subjects), but lipid-soluble vitamin (A, D, E) intake often fell short of the RDI. The diet of severely obese patients is unbalanced, with high calorie intake paralleled by insufficient micronutrient intake. When these patients are assessed and managed, qualitative dietary changes should be considered in addition to routine caloric restriction.

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Key words: *Obesity. Food consumption. Dietary Reference Intakes (DRI).*

¿OBESIDAD COEXISTE CON LA DESNUTRICIÓN? ADECUACIÓN DEL CONSUMO DE ALIMENTOS DE LOS PACIENTES OBESOS A LAS RECOMENDACIONES DE INGESTA DIETÉTICA DE REFERENCIA

Resumen

Evaluar la adecuación de la dieta de los pacientes con obesidad severa y describir las principales deficiencias nutricionales a través del DRI. Los pacientes fueron seleccionados de forma secuencial, lo que indica la cirugía bariátrica en el periodo de marzo 2010 a noviembre 2011. Todos los pacientes fueron sometidos a la evaluación del estado nutricional (antropometría y la ingesta dietética) y metabólicos (perfiles de lípidos, hormonas y glucosa). Se evaluaron 77 pacientes (edad media ± DE) de 44,48 ± 12,55 años. Cincuenta pacientes (76,6% de la muestra) eran mujeres. Las comorbilidades más frecuentes fueron la hipertensión arterial (72,4%), trastorno por atracón (47,4%), diabetes mellitus (32.9%), apnea del sueño (30,3%) y la dislipemia (18,4%). El consumo de nutrientes fue generalmente adecuada, teniendo en cuenta la ingesta calórica alta. Sin embargo, se identificaron algunas deficiencias de micronutrientes. Sólo 19,5% de los pacientes alcanzar la ingesta recomendada mínima de potasio, de calcio 26,0%, y 66,2% de hierro. En cuanto a sodio, toda la muestra alcanza el mínimo recomendado, sin embargo, llegar a la UL 98,7% para el sodio. Las vitaminas del grupo B han evaluado el consumo satisfactorios, llegando a más del 80% de las necesidades, pero las vitaminas liposolubles A, D y E se consume a menudo por debajo de la ingesta diaria recomendada. La dieta del paciente obeso no está equilibrado. Un gran consumo de calorías se acompaña de una ingesta deficiente de micronutrientes. En la evaluación de estos pacientes, cambios en la dieta cualitativos deben ser considerados simultáneamente con la restricción calórica.

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Introduction

Bariatric surgery is regarded as the most effective therapy for substantial weight reduction and weight loss maintenance in patients with severe obesity. However, it carries the risk of specific nutritional deficiencies that increase postoperative morbidity and mortality and must be identified and addressed[1-3]. Adults whose diets do not provide an adequate intake of calories, protein, or other nutrients required for tissue homeostasis and repair are considered malnourished[4].

There have been few reports on the preoperative nutritional status of these patients. From a cultural standpoint, obesity is regarded as an "overnourished" state, and the image of obese individuals is not associated with any specific nutritional deficiencies. In fact, the detailed assessment of food consumption, and of certain dietary behaviors as risk factors in the obese patient is often hindered by the characteristics of the available instruments and methods, which discourage their use in routine clinical practice. Underreporting, which is common in these patients, may also be a contributing factor[5]. Therefore, the description of dietary intake patterns in the obese population remains controversial, particularly with respect to micronutrients.

Several studies have reported micronutrient deficiencies after bariatric surgery. In some cases, these deficiencies may lead to clinical manifestations, ranging from mild, transient disturbances to irreversible neurologic changes. Clinical symptoms range from sensory neuropathy to frank encephalopathy and are most commonly caused by thiamine, copper, and vitamin B complex deficiency[6]. There is little data on preoperative micronutrient deficiencies in morbidly obese patients. Some studies have reported vitamin D deficiency as the most prevalent of these, affecting 57% to 94% of severely obese persons[1,3]. Calcium, magnesium, vitamin B6, and iron deficiency have also been described[1,37]. In the long run, these nutrient deficiencies may have yet-unknown impacts, particularly when associated with the deficiencies induced by bariatric surgery.

Food consumption before bariatric surgery in the severely obese is a factor that warrants more thorough investigation, as it can aid recovery and maintenance of adequate nutritional status in the postoperative period. As expected, the calorie intake of obese individuals is usually excessive; nevertheless, insufficient intake of essential nutrients may occur, leading to undiagnosed deficiencies. Within this context, the objective of this study was to assess food consumption by severely obese patients and describe their main nutritional deficiencies on the basis of Dietary Reference Intake (DRI).

Patients and Methods

All morbidly obese patients referred to the outpatient Endocrinology clinic –general center of endocrinological diseases treatment– of Hospital de Clínicas de Porto Alegre (HCPA) for evaluation of a potencial indication of bariatric surgery, according to the Brazilian guidelines[8], between March 2010 and November 2011 were sequentially invited to take part in the study. All 140 invited patients agreed to participate, however only 77 completed all evaluations. All prospective subjects were informed of the nature of the study and gave written informed consent for participation.

Nutritional status assessment included anthropometric examination and an evaluation of food consumption. The anthropometric parameters assessed were weight, height, mid-upper arm circumference (MUAC), waist circumference (WC), and hip circumference (HC). Weight (kg) was measured with a digital physician scale (Filizola, Brazil, resolution 0.1 kg) while barefoot and wearing lightweight clothes. Height (m) was measured with a wall-mounted stadiometer (Sanny, Brazil), with the patient standing and the head aligned in the Frankfurt plane. Body mass index (BMI) was calculated by dividing the weight by the height squared. MUAC (cm) was measured at the midpoint between the acromion and olecranon, over the posterior aspect of the relaxed arm on the non-dominant side. WC (cm) was measured at the midpoint between the lowest rib and the iliac crest. HC (cm) was measured at the level of the greatest protrusion of the gluteal area. The waist–to–hip ratio (WHR) was then calculated. All circumferences were measured using non-stretch fiberglass measuring tape (Wiso, Brazil). All measurements were performed in accordance with Brazilian Ministry of Health Food and Dietary Surveillance System recommendations[9].

Assessment of dietary intake included three 24-hour dietary recalls, with foods weighed and measured using digital kitchen scales and a measuring cup[10,11] and a semi-structured nutritional interview. Nutritional calculations were carried out with the Nutribase 7.18 software (CyberSoft, USA). The basal metabolic rate (BMR) was calculated on the basis of established formulae for overweight adult men and women [12]. The DRIs used for analysis and comparison are listed in table I[12-17].

The metabolic panel consisted of measurement of the following parameters: triglyceride (TG) and total cholesterol (TCHOL) levels, by the enzymatic colorimetric method (Hitachi 917, Roche, Brazil); HDL cholesterol, by a homogeneous enzymatic colorimetric assay (Hitachi 917, Roche, Brazil), LDL cholesterol, estimated by the Friedewald formula [18]; serum glucose, by the colorimetric glucose oxidase method (Hitachi 917, Roche, Brazil); glycated hemoglobin (A1c%) by immunoturbidimetric assay (Hitachi 917, Roche, Brazil); insulin, TSH, and T4 by electrochemiluminescent immunoassay (ECLIA) (Modular E-170, Roche, Brazil); C-reactive protein (CRP) by nephelometry (BNII Nephelometer, DSP, Brazil); and total serum calcium, by the *o*-cresolphthalein complexone method (Hitachi 917 Roche, Brazil). All tests were performed at the Clinical Pathology Service of the hospital. Any

Table I
Recommended nutrient intakes

Nutrient	*EAR*	*RDA*	*AI*	*UL*
Protein (g/kg/day) (Males and females, > 18 y)	0.66	0.8	–	–
Protein, % calories from (Males and females, > 18 y)	–	10-35	–	–
Carbohydrate (g/day) (Males and females, > 18 y)	100	130	–	–
Carbohydrate, % calories from (Males and females, > 18 y)	–	45-65	–	–
Lipids, % calories from (Males and females, > 18 y)	–	20-35	–	–
Fiber (g/day)				
Males, 18-50 y	–	–	38	
Males, > 51 y	–	–	30	
Females, 18-50 y	–	–	25	
Females, > 51 y	–	–	21	
Calcium (mg/day)				
Males, 18-70 y	800	1000	–	2500
Males, > 71 y	1000	1200	–	2000
Females, 18-50 y	800	1000	–	2500
Females, > 51 y	1000	1200	–	2000
Iron (mg/day)				
Males, > 18 y	6	8	–	45
Females, 18-50 y	8.1	18	–	45
Females, > 51 y	5	8	–	45
Zinc (mg/day)				
Males, > 18 y	9.4	11	–	40
Females, >18 y	6.8	8	–	40
Sodium (g/day)				
Males and females, 18-50 y	–	–	1.5	2.3
Males and females, 50-70 y	–	–	1.3	2.3
Males and females, > 70 y	–	–	1.2	2.3
Potassium (g/day) (Males and females, > 18 y)	–	–	4.7	N/A
Vitamin A (μg/day)				
Males, > 18 y	625	900	–	3000
Females, >18 y	500	700	–	3000
Vitamin B12 (μg/day)	2.0	2.4	–	N/A
Vitamin B6 (μg/day)				
Males and females, 18-50 y	1.1	1.3	–	100
Males, > 50 y	1.4	1.7	–	100
Females, > 50 y	1.3	1.5	–	100
Vitamin D (μg/day)				
Males and females, 18-70 y	10	15	–	100
Males and females, > 70 y	10	20	–	100
Vitamin E (mg/day) (Males and females, > 18 y)	12	15	–	1000

EAR, Estimated Average Requirement; RDA, Recommended Dietary Allowance; AI, Adequate Intake; UL, Tolerable Upper Intake Level. After *Dietary Reference Intakes (DRI)*. Retrieved from <www.nap.edu> in April 2012[12-17].

comorbidity diagnosed on laboratory testing was confirmed by review of the patients' past medical history, current medications, and medical records.

Statistical analyses were carried out in the SPSS v.20 software. Results are expressed as means and standard deviation (SD), percentages, or median and range (for variables not normally distributed). A $p<0.05$ was chosen as the significance level. The study was approved by the Hospital de Clínicas de Porto Alegre research ethics committee.

Results

A total of 77 patients were assessed, 50 of whom (76.6%) were female. Mean age was 44.48 ± 12.55 years. The self-reported ethnic makeup of the sample was 69.7% white, 13.2% black, 10.5% brown, 2.6% Native Brazilian and 3.9% other. The most prevalent comorbidities were hypertension (72.4%), binge eating disorder (47.4%), diabetes mellitus (32.9%), sleep apnea (30.3%) and dyslipidemia (18.4%). Mean weight was 129.90 ± 25.78 Kg, and BMI, 48.8 ± 8.3 kg/m². The clinical and anthropometric profile of the sample is described in table II.

Regarding dietary characteristics, 97.4% of subjects had received some form of dietary counseling before. Most (77%, n = 60) ate only two meals a day. Breakfast (21.1%), mid-morning snack (72.4%), afternoon snack (23.7%) and supper (67.1%) were often skipped. Furthermore, over half of all subjects (51.3%) had no defined meal schedule. Dairy intake was exceedingly low, with 17.1% of subjects consuming no dairy whatsoever and no supplemental calcium. Only 23.7% of subjects ate and drank skim or fat-free dairy products. Calcium intake by female subjects was highly variable (723.3 [105.9–5647.5] mg/day).

Mean BMR was 1970.92 ± 354.08 Kcal/day, lower than mean calorie intake (2782.75 ± 1131.43 kcal/day). Mean macronutrient intake was within the adequate range: 19.38±6.9% of daily calories from protein, 51.16±10.47% from carbohydrate, and 29.69 ± 6.8% from lipids. Although there is no established DRI for saturated fats, Brazilian Cardiology Society guidelines for non-pharmacological treatment of dyslipidemia and atherosclerosis prevention recommend that no more than 7% of daily calories come from saturated fat[19]. In the study sample, this percentage was 8.44 ± 2.19%.

The distribution of nutrient intake in this population is described in table III. There were marked differences between the usual diets of male and female obese patients, and marked gender differences on comparison of intake adequacy (Table IV).

Discussion

The finding that food consumption by severely obese patients is largely, and variably, unbalanced is neither unexpected nor unusual, despite this, only our study and another recent publication evaluated the malnutrition based on DRIS[20]. In this series, some patients only met minimum intake recommendations for some nutrients, whereas others failed to reach intake recommendations for some nutrients while reaching the Tolerable Upper Intake Levels (ULs) of other dietary components.

Table II
Clinical and anthropometric parameters

Parameter	*Overall*	*Females*	*Males*	*p*[a]
Weight (kg)	129.90±25.78	123.6 ± 21.3	149.8 ±29.2	<0.001¹*
BMI (kg/m²)	48.8 ± 8.3	48.2 ± 7.7	50.7 ± 9.9	0.270¹
Height (m)	1.62 ± 0.09	1.6 ± 0.07	1.7 ± 0.09	<0.001¹*
BMR (Kcal/day)	1971.0 ± 354.1	1830.1 ± 211.3	2432.6 ± 337.1	<0.001¹*
MUAC (cm)	44.7 ± 12.6	45.3 ± 14.0	42.9 ± 6.5	0.500¹
WC (cm)	137.7 ± 16.8	134.5 ± 15.1	150.5 ± 17.8	<0.001¹*
HC (cm)	138.9 ± 19.5	138.2 ± 19.5	141.4 ± 20.0	0.551¹
WHR	1.01 ± 0.2	1.0 ± 0.2	1.1 ± 0.09	0.313¹
TCHOL (mg/dL)	184.5 ± 37.8	186.2 ± 34.3	179.6 ± 48.3	0.566¹
HDL (mg/dL)	41.3 ± 10.1	43.3 ± 10.4	35.1 ± 5.9	<0.002¹*
LDL (mg/dL)	110.0 ± 31.6	111.3 ± 0.0	105.7 ± 40.3	0.526¹
TG (mg/dL)	144 (56- 742)	134 (56 -404)	166. 0 (62 – 742)	0.200²
Calcium, total serum (mg/dL)	8.8 ± 0.4	8.9 ± 0.4	8.9 ± 0.3	0.896¹
CRP (mg/L)	10.6 (4 – 51.6)	11.3 (4.0-51.6)	5.3 (4.0 -29.5)	0.007²*
Glucose (mg/dL)	123.2 ± 39.7	122.5 ± 41.3	125.7 ± 35.2	0.769¹
A1c (%)	6.9 ± 1.7	6.8 ± 1.8	6.9 ± 1.3	0.826¹
Insulin (µU/ml)	27 (4.5 – 172.7)	31.6 (9.1-172.7)	32.8 (4.5 – 122.1)	0.219²
T4 (µg/dL)	9.1 ± 2.1	9.3±1.9	8.3 ± 2.6	0.075¹
TSH (µUI/mL)	3.0 (0.2 – 14.9)	3.3(0.2- 14.8)	2.8(1.3-5.6)	0.184²

BMI, body mass index; MUAC, mid-upper arm circumference; WC, waist circumference; HC, hip circumference; WHR, waist–hip ratio; TCHOL, total cholesterol; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; TG, triglycerides; CRP, C-reactive protein; A1c, glycated hemoglobin; BMR, basal metabolic rate. Data expressed as mean ± standard deviation or median (interquartile range) as appropriate. ¹*t*-test for independent samples. [a]P-value for between-gender differences. ²Mann–Whitney *U*. α = 0.05.

Table III
Dietary parameters

Parameter	*Overall*	*Females*	*Males*	*p*[a]
Kcal (total)	2782.7 ± 1131.4	1595.4 ± 998.5	3396.31 ± 1341.9	0.008[1]*
PTN (g/day)	114.0 (41.8-457.1)	107.2 (41.8 -366.6)	145.1 (86.4-457.1)	0.002[2]*
PTN (g/kg/day)	0.9 (0.3-3.4)	0.9 (0.3- 3.4)	1.1 (0.6 – 3.1)	0.097[2]
CHO (g/day)	355.9 ± 163.9	342.8 ± 158.2	398.9 ± 179.3	0.250[1]
LIP (g/day)	91.6 ± 44.8	83.9 ± 40.0	116.7 ± 51.2	0.006[1]*
LIP, SAT (g/day)	26.3 ± 13.9	23.4 ± 11.9	35.8 ± 15.9	0.001[1]*
LIP, UNS (g/day)	48.3 (15.0-163.6)	44.5 (15.0 – 161.6)	58.8 (27.21 -163.6)	0.020[2]*
Fiber (g/day)	23.6 (5.7 – 79.6)	22.6 (5.7 – 72.7)	26.8 (8.6 – 79.6)	0.033[2]*
Ca (mg/day)	733.1 (105.9-5647.5)	723.3 (105.9 – 5647.5)	845.6 (361.5 – 1989.5)	0.386[2]
Fe (mg/day)	17.58 (5.0-53.8)	15.8 (5.0 -35.3)	25.3 (9.0 – 53.8)	<0001[2]*
Zn (mg/day)	15.84 (4.6-49.9)	14.2 (4.6 -38.1)	22.8 (13.1 – 49.9)	<0.001[2]*
Na (mg/day)	5458.0 ± 2516.4	5361.2 ± 2315.9	5775.3 ± 3141.8	0.545[1]
K (mg/day)	3367.4 ± 1787.5	3242.3 ± 1840.4	3777.5 ± 1580.0	0.269[1]
B12 (μg/day)	5.0 (0.7-67.0)	4.0 (0.7 – 67.0)	9.0 (3.38 – 42.54)	<0.001[2]*
B6 (mg/day)	2.2 ± 1.0	2.0 ± 0.9	2.9 ± 1.2	0.003[1]*
Vit. A (μg/day)	91.9 (84.5 – 9042.6)	623.4 (84.5- 9042.6)	750.4 (306.2 –5007.6)	0.393[2]
Vit. D (μg/day)	0.4 (0.0 – 33.4)	0.3 (0.0 – 33.4)	0.5 (0.0 -3.59)	0.766[2]
Vit. E (mg/day)	5.9 ± 2.9	5.7 ±3.0	6.4 ± 2.7	0.386[1]

Kcal, total calorie intake; PTN, protein; CHO, carbohydrate; LIP, lipids; SAT LIP, saturated fat; UNS LIP, unsaturated fat; Ca, dietary calcium; Fe, dietary iron; Zn, dietary zinc; Na, dietary sodium; K, dietary potassium; B12, dietary vitamin B12; B6, dietary vitamin B6; Vit.A, dietary vitamin A; Vit.D, dietary vitamin D; Vit.E, dietary vitamin E. [1]*t*-test for independent samples. [a]P-value for between-gender differences. [2]Mann–Whitney *U*. α = 0.05.

Table IV
Adequacy of dietary intake

Parameter	*Percentage of patients with adequate intake* *Overall*	*Females*	*Males*	*p*[a]
PTN (g/day)	98.7%	98.3%	100%	0.58
PTN (g/kg/day)	76.6%	72.9%	88.9%	0.16
CHO (g/day)	97.4%	96.6%	100%	0.43
Fiber (g/day)	44.2%	45.8%	38.9%	0.61
Ca (mg/day)	26.0%	23.7%	33.3%	0.42
Fe (mg/day)	66.2%	55.9%	100%	<0.001*
Zn (mg/day)	89.6%	86.4%	100%	0.09
Na (mg/day)	100%	100%	100%	1
K (mg/day)	19.5%	15.3%	33.3%	0.09
B12 (μg/day)	88.3%	84.7%	100%	0.08
B6 (mg/day)	80.5%	74.6%	100%	0.02*
Vit. A (μg/day)	42.9%	45.8%	33.3%	0.35
Vit. D (μg/day)	49.4%	47.5%	55.6%	0.55
Vit. E (mg/day)	1.3%	1.7%	0%	0.58

Kcal, total calorie intake; PTN, protein; CHO, carbohydrate; LIP, lipids; SAT LIP, saturated fat; UNS LIP, unsaturated fat; Ca, dietary calcium; Fe, dietary iron; Zn, dietary zinc; Na, dietary sodium; K, dietary potassium; B12, dietary vitamin B12; B6, dietary vitamin B6; Vit. A, dietary vitamin A; Vit. D, dietary vitamin D; Vit. E, dietary vitamin E. [1]*t*-test for independent samples. [a]P-value for between-gender differences. [2]Mann–Whitney *U*. α = 0.05.

Adequacy rates were high for macronutrient intake. However, it bears stressing that "adequacy" is defined as a minimum intake level rather than a range of intake. Therefore, even patients whose macronutrient consumption was excessive, thus leading to high calorie intake, were within the DRI adequacy rate. It bears stressing too that DRI do not necessarily meet the metabolic needs of obese individuals. Especially in physiologic stress situations like significant weight loss or periods of weight cycling, obese patients potentially need different amounts of micronutrients[20].

Although 98.7% of subjects in this sample had adequate protein intake (i.e. their protein consumption meets the minimum intake level), intake was more than twice as high as current recommendations (112 g/day for men and 92 g/day for women) in 54.5%; in 27.3% of subjects, protein intake (1.75 ± 0.6 g/kg/day) even exceeded that of a high-protein diet (≥1.25 g/kg/day).

Carbohydrate intake patterns were similar, with 97.4% of subjects meeting the minimum daily intake recommendation and 67.5% consuming more than twice as much as the current reference intake (230 g/day). Quantitative assessment of macronutrient intake adequacy is hindered by the unavailability of ULs for these dietary components, as well as the unavailability of recommended lipid intake levels in g/day.

Analysis of macronutrient intake as a proportion of total energy intake also revealed an unbalance in the distribution of calorie intake. In 98.7% of patients, the percentage of calories from protein meets the minimum recommended level. However, 24.7% of patients do not consume the minimum recommended amount of carbohydrate and 28.6% do not consume the minimum recommended amount of dietary fat. Therefore, in the usual diet of these patients, the contribution of protein to total calorie intake exceeds recommendations. This corroborates the statement that these subjects follow a high-calorie diet.

As protein intake was elevated and dairy intake was low, we conclude that protein is provided by overconsumption of meats. Accordingly, mean saturated fat intake was also high (8.44 ± 2.19% of calories from saturated fat). Furthermore, less than half of subjects met minimum fiber intake recommendations (44.2%). This set of inadequacies constitutes a potentially atherogenic diet.

Concerning micronutrients, potassium intake was below recommended levels in 80.5% of patients, and calcium intake was insufficient in 74% of cases, although calcium intake was insufficient, this does not seem to affect mean total serum calcium 8.8 ± 0.4 mg / dL (recommend 8.6 to 10.0 mg/dL). But, a variety of studies have reported a correlation between calcium intake and overweight or obesity. Several pathways of calcium metabolism may be associated with body weight control. Furthermore, there is consistent evidence that calcium and vitamin D increase body fat oxidation. In the gastrointestinal tract, calcium binds fatty acids, promoting energy loss by means of a modest increase in fecal lipid excretion. The main theory, however, concerns body temperature regulation and thermogenesis. Intracellular calcium levels play a major role in several metabolic processes, and influence hormone-including parathyroid hormone-and vitamin D levels. High intake of this mineral would boost diet-induced thermogenesis, increase lipolysis, and suppress major lipogenic metabolic pathways, as well as reduce hunger. Recent evidence also suggests that calcium intake is associated with improved insulin sensitivity[21,22].

In this series, there were significant gender differences in iron intake and DRI adequacy ($P < 0.001$). Iron deficiency is the most common of all dietary deficiencies[23]. In addition to inadequate intake, as observed in this sample, some studies have reported significant iron, ferritin and hemoglobin deficiency on preoperative testing in morbidly obese individuals[24,25].

Sodium intake exceeded minimum recommended levels in 100% of the sample, due to high consumption of sodium-rich industrialized foods and to the habit of adding salt to foods during cooking or at the table. Remarkably, 98.7% of patients exceeded the current UL for this nutrient. This is particularly notable in view of the fact that hypertension was the most prevalent comorbidity in our sample (72.4%).

Hypertension is the main risk factor for premature death. A sodium-rich diet is a major contributor to high blood pressure and is strongly associated with other diseases, such as stomach cancer, kidney stones, osteoporosis, asthma and obesity[26].

In addition to sodium ULs, 2.6% of subjects reached the UL for iron and 3.9% for zinc. Zinc toxicity is rare; excessive iron intake, however, may contribute to increased oxidative stress, with greater free radical formation and endothelial damage, as well as facilitate oxidation of LDL cholesterol[23]; both factors contribute to cardiovascular disease.

Vitamin B complex intake was satisfactory in this sample, with over 80% of subjects having adequate intake. Conversely, intake of fat-soluble vitamins-A, D, and, particularly, E-was largely insufficient. Only 1.3% of subjects had adequate vitamin E intake; no male subjects met the minimum recommended intake. Vitamins A and E play an important role as antioxidants, and are particularly protective against LDL cholesterol oxidation. Low carotenoid (vitamin A) and alpha-tocopherol levels have also been implicated in increased oxidative stress, insulin resistance and development of malignancies[27].

Studies have shown that vitamin D deficiency, hyperparathyroidism and bone loss are potential complications of bariatric surgery[28-30]. This study demonstrates that, even before weight loss surgery, the diet of severely obese patients is deficient in vitamin D and calcium, which could contribute to postoperative complications. Therefore, these nutrients must be carefully assessed in the preoperative period. According to a recent review, patients lose bone mass, particularly in the hip, after bariatric surgery. However, there are no conclusive data on the incidence of osteoporosis or fracture risk in patients undergoing these procedures[31].

Assessment of food consumption in this sample was subject to under- or overestimation. Despite its fallibility, weighing is the most reliable method for measurement of food intake, the method of nutritional evaluation used in this study is the preferred instrument in clinic practice, and a reliable tool to evaluate food consumption[32,33].

The dietary patterns of severely obese women and men are distinct. Nutritional deficiencies were less prevalent in men. On all parameters assessed in this study except for calcium and vitamin E, men also achieved higher intake adequacy rates than women. Therefore, we may conclude that the quality of food consumption is poorer in obese women than in obese men. However, further assessment of these parameters while adjusting nutrient intake to body weight is warranted, to address whether these gender differences in nutritional parameters remain and are not only a reflection of the fact that absolute, rather than relative, values were used in our analyses.

Men had a pattern of obesity with a higher weight, as expected. Besides that, they had larger waist circumference, greater caloric and saturated fat intakes. Since protein intake was also higher in men, we speculate that this is related to a high intake of red meat, which is quite common in southern Brazil[34]. Men had lower HDL-c values compared to the women. Women, on other hand, tended to present binge eating with a higher frequency, a diet richer in carbohydrates, and a higher CRP. Although the frequencies of hypertension and dyslipidemia were similar, a higher CRP could indicate a different inflammatory environment in these women, with implications that have yet to be studied.

The very high BMI in our sample could explain the high prevalence of comorbidities. Local environmental factors, such as food and physical activity habits, and genetic characteristics of our population (both poorly studied) should be seen as potential variables associated with the high prevalence of comorbidities in these patients. Furthermore the patients has no common changes in metabolism (such as hypothyroidism or subclinical hypothyroidism) that could explain the high caloric intake or BMI. Another factor that must be considered is the very difficult access to qualified centers, and the long waiting time for treatment with specialists in the Brazilian Public Health System. This could play a role on the progression of the disease, culminating in a higher frequency of severe cases. This hypothesis needs to be tested.

It is widely known that very low-calorie diets are associated with high failure rates in severely obese patients; qualitative dietary changes might benefit this population without necessarily involving sudden reductions in energy intake. A recent study shows that even getting a diet with 100% of the DRIs adequacy obese continue have nutrient deficiencies[20], therefore, changes in diet must be done carefully. In practice, the acceptance of qualitative changes is superior to that of very low-calorie diets. Certain supplements can be useful in cases of low micronutrient intake. Nevertheless, the implementation of dietary changes should be preferred, as overconsumption of dietary supplements is often more harmful than beneficial to health and can increase the risk of drug–drug and food–drug interactions, as medication use rates are high in these patient population[35]. The limitations of this study include its single-center design, which limits generalization of the findings. Furthermore, the relatively small sample size and predominance of female subjects may have affected our interpretation of results.

In short, the usual diets of obese subjects are not only unbalanced, but highly atherogenic, excessively reliant on industrialized foods and high in sodium, and deficient in essential nutrients, a combination that leads to high risk of atherosclerosis and cardiovascular disease, affects immunity, and increases the risk of cancer and other chronic noncommunicable diseases. These issues cannot be ignored; however, any changes to the diet of severely obese persons must be undertaken with extreme care, as they might aggravate already poor essential nutrient intake. Qualitative dietary changes must be made on a case-by-case basis, after analysis of the characteristics of each patient and their probable nutrient deficiencies.

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