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Anthropometric, food intake differences and aplicability of low-cost instruments for the measurement of body composition in two distinct groups of individuals with short bowel syndrome

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Abstract

Introduction: **Short bowel syndrome is associated with weight loss due to nutrient, electrolyte and fluid malabsorption. In view of the pathophysiology of SBS, all patients would be expected to exhibit similar clinical signs and symptoms, whereas many variations occur probably due to the adaptive capacity of the remaining small intestine in order to compensate for the resected area.**

Objective: **To determine whether there is a difference in nutritional status and food intake between patients receiving PNT, patients who do not receive PNT but are monitored on an ambulatory basis, and control subjects, and 2) to determine body composition by two different methods, i.e., electrical bioimpedance and skin fold measurement.**

Methods: **This was a case-control study where the subjects were divided into three groups: parenteral group (PG) – adults with a history of SBS intermittently using PNT; ambulatory group (AG) – adults with a history of SBS who do not receive PNT; control group (CG) – adults with no history of intestinal resections and/or use of PNT. The volunteers were submitted to measurements of body weight, height, body composition by bioimpedance analysis and assessment of food intake using a food frequency questionnaire. Univariate analysis of variance (ANOVA) with the aid of the SAS® 9.2. software, using the PROC GLM feature. The Student t-test was used to compare the instruments for the assessment of body composition, with the aid of the PROC TTEST feature of the SAS® 9.2 software.**

Results: **Thirty-two volunteers, 19 women and 13 men, participated in the study. The PNT group consisted of 9 volunteers, 4 women and 5 men, with a mean (± SD) age of 57 ± 9 years. The nutrition status and food intake were different between the groups. There was no difference in percent body fat measured by anthropometry and bioimpedance analysis.**

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ANTROPOMETRÍA, DIFERENCIAS EN EL CONSUMO DE ALIMENTOS Y APLICABILIDAD DE INSTRUMENTOS DE BAJO COSTE PARA LA MEDICIÓN DE LA COMPOSICIÓN CORPORAL EN DOS GRUPOS DISTINTOS DE INDIVIDUOS CON SÍNDROME DEL INTESTINO CORTO

Resumen

Introducción: **El síndrome del intestino corto se asocia con pérdida de peso por la malabsorción de nutrientes, electrolitos y líquidos. A la vista de la fisiopatología del SIC, se esperaría que todos los pacientes exhibieran signos y síntomas clínicos similares, mientras que pueden ocurrir variaciones probablemente por la capacidad de adaptación del intestino delgado restante con el fin de compensar el área resecada.**

Objetivo: **Determinar si existen diferencias en el estado nutritivo y en el consumo de alimentos entre pacientes que reciben TNP, aquellos que no reciben TNP pero que están monitorizados de forma ambulatoria e individuos control, y 2) determinar la composición corporal mediante dos métodos distintos: la bioimpedancia eléctrica y la medición del pliegue cutáneo.**

Métodos: **Éste fue un estudio de casos-control en el que se dividió a los sujetos en tres grupos: el grupo de parenteral (GP) – adultos con una historia de SIC y con uso intermitente de TNP; grupo ambulatorio (GA) – adultos con una historia de SIC que no recibían TNP; grupo control (GC) – adultos sin antecedentes de resecciones intestinales ni uso de TNP. Los voluntarios fueron sometidos a mediciones del peso corporal, talla, composición corporal mediante análisis de bioimpedancia y evaluación del consumo de alimentos utilizando un cuestionario de frecuencia de alimentos. Se realizó un análisis de varianza (ANOVA) con la ayuda del programa SAS® 9.2, utilizando la aplicación PROC GLM. Se empleó el test t de Student para comparar los instrumentos de la evaluación de la composición corporal, con la ayuda de la aplicación PROC TTEST del programa SAS® 9.2.**

Resultados: **32 voluntarios, 19 mujeres y 13 hombres, participaron en el estudio. El grupo TNP estaba compuesto de 9 voluntarios, 4 mujeres y 5 hombres, con una edad media (± DE) de 57 ± 9 años. El estado nutritivo y el consumo de alimentos fueron diferentes entre los grupos. No hubo diferencias en el porcentaje de grasa corporal medida por antropometría y análisis de bioimpedancia.**

Discussion and conclusion: **Large resections, as well as the resected portions, explain the greater nutritional impairment of PG compared to AG and CG, although no significant difference in food consumption was detected between these three groups. Since the use of PNT can lead to a state of hyperhydration, the results of BIA should be interpreted with caution, in view of the fact that the lean mass determined by this method varies positively with the hydration state of an individual.**

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Key words: *Short bowel syndrome. Body composition. Food intake.*

Discusión y conclusión: **Las resecciones largas, así como las porciones resecadas, explican la mayor alteración nutricional del grupo GP en comparación con los grupos GA y GC, aunque no se detectaron diferencias significativas en el consumo de alimentos entre los tres grupos. Puesto que el empleo de TNP puede conducir a un estado de hiperhidratación, los resultados del ABI deberían interpretarse con precaución puesto que la masa magra determinada por este método varía positivamente con el estado de hidratación de un individuo.**

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Palabras clave: *Síndrome del intestino corto. Composición corporal. Consumo de alimentos.*

Introduction

Short bowel syndrome (SBS) is usually due to intestinal ischemia or necrosis, neoplasias, postoperative complications, benign causes, or inflammatory bowel disease[1-3], which culminate in extensive areas of enterectomy. The result is the loss of the absorptive area and of the processes of site-specific transport, with impaired gastrointestinal hormone secretion and, in some cases, loss of the ileocecal valve, factors that involve intense weight loss and nutrient, electrolyte and fluid malabsorption. In addition, there is gastric hypersecretion, inactivation of pancreatic enzymes, loss of bile salts with a shorter intestinal transit time, osmotic diarrhea, steatorrhea, vitamin deficiencies, hypovolemia, hyponatremia and hypokalemia, and an increased incidence of nephrolithiasis and cholelithiasis[1,3,4].

It has been reported that an intestinal length of 100 cm would be sufficient to maintain absorptive capacity and that absorption would be maintained without the need for support with parenteral nutrition therapy if the colon, ileocecal valve and at least 40 cm of the small bowel were preserved[5]. Other more conservative authors have stated that greater impairment of nutritional status associated with the risk of cholelithiasis occurs when the remaining intestine is shorter than 120 cm without the colon or shorter than 60 cm even with continuity of the colon, with the patients requiring parenteral nutrition therapy (PNT) for the recovery and/or maintenance of nutritional status[3,6] stated that usually patients with 180 cm of remaining intestine do not require PNT, whereas patients with 90 cm and the colon in continuity require PNT for approximately one year and, in agreement with[3], patients with 60 cm of remaining intestine require permanent PNT even with the colon in continuity.

In view of the pathophysiology of SBS, all patients would be expected to exhibit similar clinical signs and symptoms, whereas many variations occur probably due to the adaptive capacity of the remaining small intestine in order to compensate for the resected area[7]. Thus, SBS is not simply defined by the length of the remaining intestine, but also by mutiple factors and variables related to the postoperative period, such as extension of the resection itself, site of resection, presence of base diseases, presence or absence of the ileocecal valve, functionality of the organs of the gastrointestinal tract, and the adaptive ability of the remainig intestine, where the adaptation phase starts[7,8].

Although adaptive processes occur, the loss of nutrients is highly significant and, as a clinical consequence, these patients progress to a situation of severe protein-calorie malnutrition[3,4,9].

The objectives of the present study were: 1) to determine whether there is a difference in nutritional status and food intake between patients receiving PNT, patients who do not receive PNT but are monitored on an ambulatory basis, and control subjects, and 2) to determine body composition by two different methods, i.e., electrical bioimpedance and skin fold measurement.

Methodology

Patients

This was a case-control study[10] conducted at the University Hospital of the Faculty of Medicine of Ribeirão Preto, University of São Paulo (HCFMRP/USP). The experimental protocol was approved by the Research Ethics Committee of HCMRP/USP (protocol no. 8667/2009) and at no time did it interfere with the clinical course of the patient or with the routine of the outpatient clinic. All patients gave written informed consent to participate in the study.

The subjects were divided into three groups: parenteral group (PG) – adults with a history of SBS intermittently using PNT; ambulatory group (AG) – adults with a history of SBS who do not receive PNT; control group (CG) – adults with no history of intestinal resections and/or use of PNT. Individuals who accepted to participate in the study and who were eligible according to the inclusion criteria, were recruited for the study.

The exclusion criteria for PG and AG patients were:

1. Refusal to permit data collection.
2. HCFMRP/USP patients who did not develop SBS.
3. Patients with a resection time of less than one year at the time of data collection.
4. Unstable patients in terms of infectious aspects (changes in more than 4 of the following parameters: systolic arterial pressure, diastolic arterial pressure, body temperature, heart rate, respiratory rate, C-reactive protein, lymphocyte count, ferritin and transferrin levels).
5. Patients whose base disease for resection was cancer.
6. Patients with resection but who did not meet the criteria for SBS.
7. Patients with SBS who do not intermittently use PNT and are not monitored on an ambulatorry basis.
8. Patients with syndromes that impair cognitive function.

The exclusion criteria for CG subjects were:

1. Refusal to permit data collection.
2. Adults with a difference of ± 2 years of age compared to AG patients.
3. Adults who had undergone any type of intestinal resection.
4. Adults who had already used PNT.
5. Unstable adults in terms of infectious aspects, i.e., changes in more than 4 of the following parameters: systolic arterial pressure (considered to be normal up to 129 mmHg), diastolic arterial pressure (considered to be normal up to 89 mmHg), body temperature (minimum limit of 37°C), heart rate (100 beats/minute), respiratory rate (normal values: 12 to 22 breaths/minute)[11-13] C-reactive protein, lymphocyte count, ferritin and transferrin.

Experimental design

Data were collected in three phases, each applied in the same order for all individuals.

Phase 1 consisted of the analysis of the medical records of AG patients, with information being obtained about name, HCFMRP/USP registration number, date of birth, remaining intestine, data recorded by the surgeon, presence or absence of the ileocecal valve, time of PNT use in months, and use or not of a lipid emulsion in PNT. Phase 2 consisted of contacting the individuals eligible for participation in the study. PG patients were invited verbally during hospitalization for PNT, AG patients were contacted by telephone or letter, and CG subjects were invited by means of posters scattered around the Hospital.

Phase 3 was devoted to data collection, involving anamnesis (age, schooling, food record (Quantitative Food Frequency Questionnaire, QFFQ), anthropometric evaluation (weight (kg), height (m), body mass index (BMI) (kg/m^2), skin folds (mm), estimate of body fat based on skin folds (percentage and kg), arm circumference (cm), arm muscle circumference (cm^2), and electrical bioimpedance (percentage and kg). Data were collected in the same place by the same investigator for all groups, in a room duly prepared for this purpose in the Clinical Research Unit on the 12th floor of HCFMRP/USP.

Anthropometry

Weight and height measurements were made and used to calculate the BMI. In addition, skin folds (bicipital, tricipital, subscapular and suprailiac folds) were measured for extrapolation of percent body fat and body fat mass (kg) and arm circumference (AC) was measured in order to obtain arm muscle circumference (AMC)[14]. Bioimpedance was also performed with the Tetrapolar Bioimpedance Biomarker 2000® instrument according to preestablished protocols.

Assessment of food intake

Food intake was determined using the QFFQ, which represents a retrospective method aiming at the detailed report of food intake over a given period of time using a food list[15]. The data obtained with the QFFQ were analyzed with the Dietsys® software to evaluate the foods consumed by the study population and to determine the correlation of the size, number and frequency of the foods consumed with nutritional status assessed by the anthropometric measurements[16].

Statistical Analysis

An exploratory analysis of the data was first performed. The basic objective of this methodology is to synthesize a series of values of the same nature in order to obtain an overall view of the variation of these values, which are organized in tables with descriptive measures and plotted on graphs. Descriptive analysis of the data was performed with the aid of the SAS® 9.2 software, using the PROC MEANS feature.

Univariate analysis of variance (ANOVA) was then used[17], with the aid of the SAS® 9.2 software, using the PROC GLM feature.

The Student t-test was used to compare the instruments for the assessment of body composition, with the aid of the PROC TTEST feature of the SAS® 9.2 software.

Results

Thirty-two volunteers, 19 women and 13 men, participated in the study. The PNT group consisted of 9 volunteers, 4 women and 5 men, with a mean (± SD) age of 57 ± 9 years. Mean time since the first resection was 6 ± 4 years. Eight subjects did not have the ileocecal valve and 1 subject had it.

The ambulatory group consisted of 10 subjects, 6 women and 4 men with a mean age of 60 ± 11 years and a mean time since the first resection of 13 ± 7 years. In this group, 5 participants had the ileocecal valve, 4 did not have it, and 1 patient had no information about it in his medical records.

In both groups the remaining intestine was shorter than 1 meter and time since first resection differed significantly between PG and AG subjects (*p = 0.02*).

The control group consisted of 13 participants, 9 women and 4 men, with a mean age of 58 ± 12 years. The three groups did not differ significantly regarding age (*p = 0.79*).

Figure 1 illustrates the analysis of food intake and shows the mean values and standard deviations of the main nutrients consumed by 1.000 kcal, with no significant difference between groups regarding any of the nutrients evaluated.

The mean (± SD) values for folate (µg/1000kcal), vitamin A (IU/1000 kcal) and vitamin E (mg/1000 kcal) for PG, AG and CG were, respectively: 99 ± 34.6 µg /1,000 kcal, 4214.2 ± 3775.4 IU/1,000 kcal and 3 ± 0.72 mg/1,000

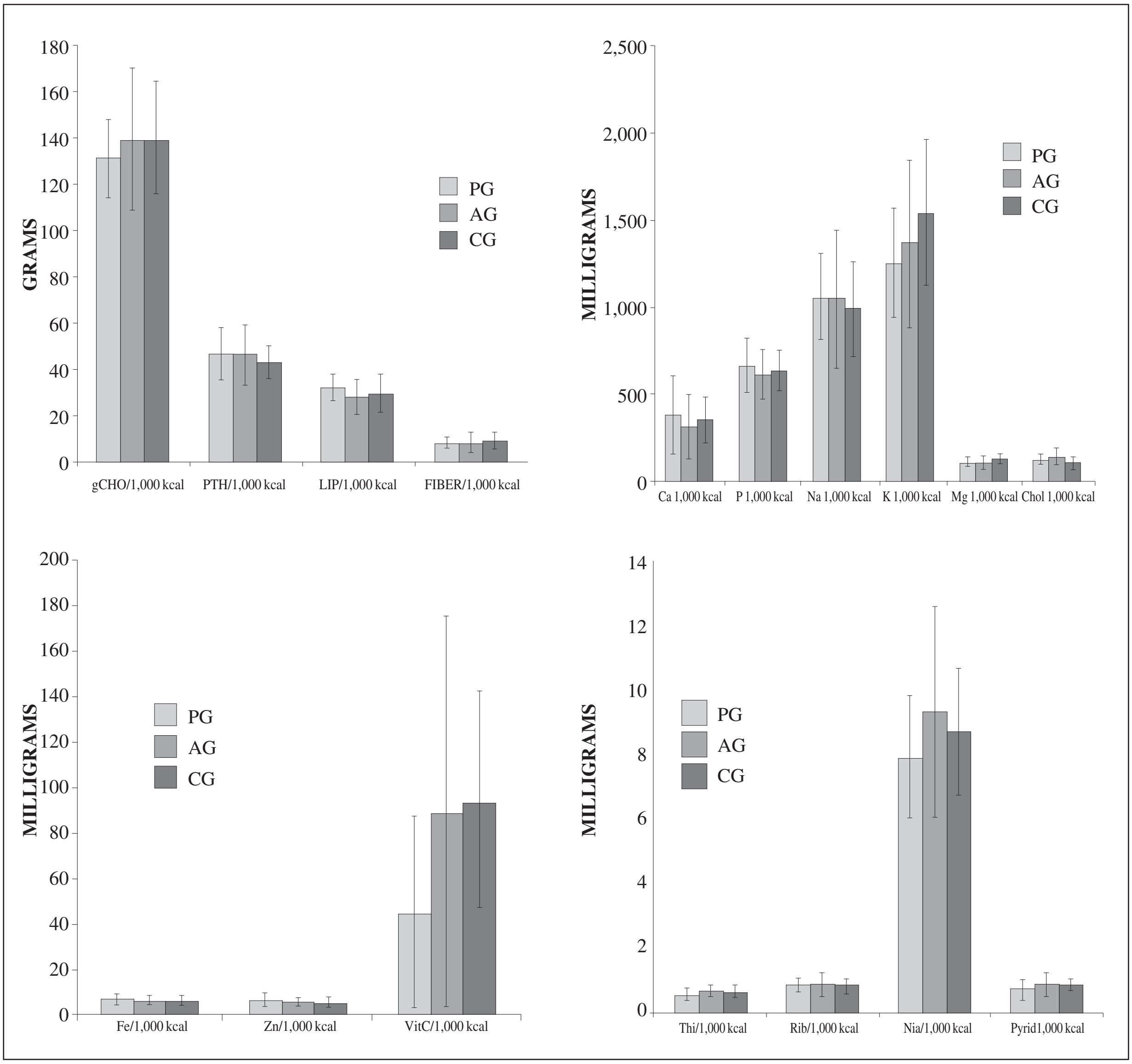

Fig. 1.—A. Mean and standard deviation of grams of carbohydrate (CH), proteins (PTH), lipids (Lip) and fibers (Fiber) per 1,000 kcal/day for each group . B. Mean and standard deviation of grams of calcium (Ca), phosphorus (P), sodium (Na), potassium (K), magnesium (Mg) and cholesterol (Chol) per 100 kcal/day for each group. C. Mean and standard deviation of milligrams of iron (Fe), zinc (Zn) and vitamin C (VitC) per 100 kcal/day for each group. D. Mean and standard deviation of milligrams of thiamine (Thi), riboflavin (Rib), niacin (Nia) and pyridoxin (Pyrid) per 100 kcal/day for each group.

kcal; 105 ± 40.5 µg /1,000 kcal, 3938.6 ± 2393.9 IU/1,000 kcal and 2.8 ± 0.7 alpha tocopherol equivalent /1,000kcal; 132.2 ± 44.2 µg/1,000 kcal, 5347.1 ± 3400.9 IU/1,000 kcal and 3.4 ± 0.9 alpha tocopherol equivalents /1,000 kcal.

The mean (± SD) values, the level of significance and the confidence interval (CI) for the data of anthropometric evaluation are given in table I.

Another variable that should be emphasized is the ileocecal valve and its possible influence on nutritional status. Figure 2 illustrates the data regarding BMI, AMC, fat mass determined with an adipometer and by bioimpedance, related to the presence or absence of the valve. The comparison of the instruments for the measurement of body composition, presented as

Table I
Mean, standard deviation, confidence interval and level of significance of the data of anthropometric assessment of the study groups

	PG	*AG*	*CG*	*p value*
BMI (kg/m²)	17 ± 2†	24 ± 5	29 ± 7†	0.0006
AC (cm)	23 ± 3†*	29 ± 5*	34 ± 6†	0.0003
AMC (cm²)	21 ± 3†	25 ± 4	27 ± 5†	0.0096
**Fat mass (kg) - Adipometer	7 ± 3†	18 ± 11	28 ± 11†	0.0008
% Body fat mass– Adipometer	16 ± 7†	28 ± 14	36 ± 10†	0.0015
***Lean mass (kg) - BIA	40 ± 7†*	40 ± 6*	48 ± 4†	0.0002
Fat mass (kg) - BIA	10 ± 4†	20 ± 8	27 ± 11†	0.0008
% Lean mass - BIA	81 ± 8†*	68 ± 7*	65 ± 7†	0.0007
% Fat mass- BIA	19 ± 8†*	40 ± 7*	35 ± 7†	0.0007
% Lean mass ACT	75 ± 4†	73 ± 2	73 ± 1 †	0.0090

†P ≤ 0.05 for the difference between PG and CG. * P ≤ 0.05 for the difference between PG and AG. ** PG patient 9 could not be submitted to all anthropometric measurements with an adipometer because he was bedridden (impossibility to measure the subscapular and suprailiac skin fold). *** PG patient 7 was not submitted to BIA because she wore a pacemaker (one of the contraindications of the use of this technology). AG patient 1 was not submitted to BIA because he did not come to the hospital on the day scheduled for this evaluation.

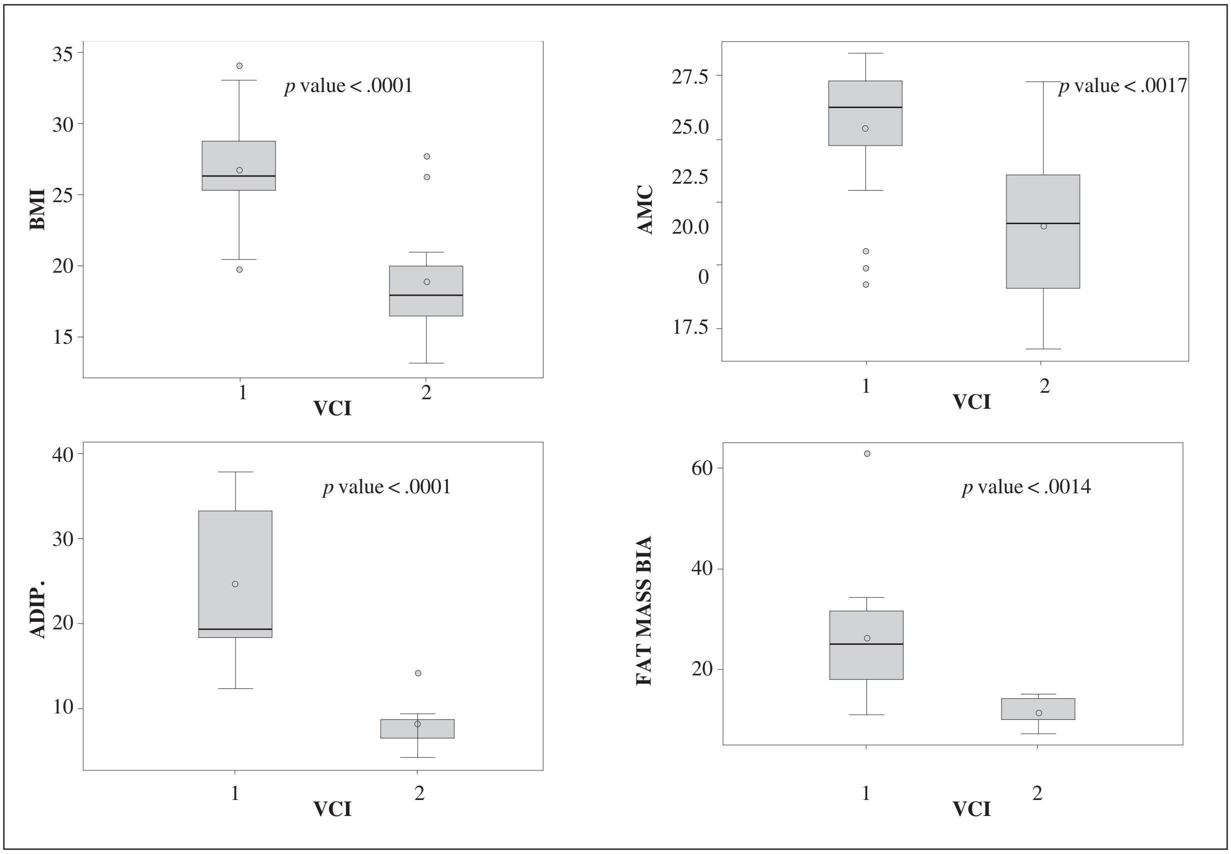

Fig. 2.—Evaluation of the influence of the presence of the ileocecal valve (identified by number 1) and its absence (identified by number 2) on the main anthropometric parameters: 2a – VCI (ileocecal valve) × BMI; 2b – VCI × AMC; 2c – VCI × amount of fat in kg determined with an adipometer; 2d – VCI × amount of fat in kg determined by BIA.

General Comparison (results of BIA and adipometer determinations without considering the group to which the subject belonged) and later presented separately for each group are listed in table II.

Discussion

The description obtained from the surgery report for intestinal resection was not well delimited regarding the remaining portions. However, there was a significant difference in time since resection between PG and AG, with this time being longer for AG. In addtion, although there were interindividual differences regarding the remaining portions, the importance of the presence of the ileocecal valve in the adaptive process and in the maintenance of nutritional status should be emphasized[18] published a case report regarding a male with only 40 cm of remaining intestine and without the ileocecal valve, with negative consequences for his nutritional status. Similarly[19], in a study on children, reported that loss of the ileocecal valve is more important regarding the presence of chronic diarrhea than the resection of the ileum or of the colon *per se*[20] also mentioned the importance of this structure in order to prevent bacterial translocation from the colon to the small bowel.

This effect is supported by the studies of Sundaram et al.[21], who stated that removal of the ileocecal valve reduces chyme emptying time from the small bowel to the colon, with a shorter time of food contact with the absorptive surface. This also increases the risk of bacterial translocation to the small bowel, causing an aggravation of nutritional status, in agreement with the results of anthropometric assessment obtained in the present study. In other words, the shorter time since the first intestinal resection (and consequently a shorter time for the adaptive process[6,8]–) and the loss of an important structure are some of the factors that may contribute to the worse nutritional status of PG subjects and a greater dependence on PNT.

Comparison of the anthropometric measures of the three groups studied here showed a moderate to severe degree of malnutrition among PG individuals compared to AG and CG individuals, as also reported in the literature. However, no significant difference in food intake was observed between groups, regardless of the nutrient involved. This agrees with data reported by Furtado et al.[22], who also detected a marked impairment of nutritional status in their SBS patients despite a similar food intake for all individuals, who live in the same region of the country and therefore have similar eating habits. Large resections definitely are a plausible explanation, since lean and fat mass depletion is one of the consequences. In addition to the similar food consumption, PG subjects receive an additional supply by means of PNT (~7 consecutive days/month), but even so their nutritional status is more impaired.

In view of this fact, the following question arises: why is it that AG individuals do not have this impairment of nutritional status even though they were also submitted to large intestinal resections? Part of this question was answered above when the preservation of the ileocecal valve was compared between groups. Another plausible answer would be the presence of an inflammatory state, i.e., possible changes in TNF-α and IL-6 levels related to the long-term use of PNT [23], which are known to act by increasing energy expenditure, anorexia, adipose and muscle reserves, and cachexia[24]. In agreement, REIMUND et. al[25] showed a positive correlation between TNF-α levels and the quantity of macronutrients infused by PNT, suggesting that the presence of this inflammatory state stimulates the catabolic pathways and increases the nutritional requirements of these individuals. Baumann et al.[26] also mentioned IL-6 and TNF-α as the main factors responsible for the increased muscle catabolism, and Bistrian et al [27] related the duration and intensity of the inflammatory state to reduction of lean body mass in individuals on dialysis.

The assessment of the nutritional status of patients with SBS is extremely important in clinical practice, since malnutrition is one of the most prevalent acute situations afer extensive resections, increasing the risk of morbidity and mortality throughout life[28].

The parameters chosen here for the assessment of body composition were based on low cost and accessibility and on the fact that they are based on noninvasive methods already established in the literature[29,30]. Although they are quite useful paameters in clinical practice, they have their limitations. However, the present study was important since, to our knowledge, there are no studies in the literature involving this type of assessment in Brazilian patients with SBS, indicating the relevance of the investigation of this population.

The data in table II permit us to infer that the two instruments for the assessment of body fat were adequate for use in this group of patients since there were no inter- or intragroup differences when the body fat mass obtained by BIA was compared to that obtained with an adipometer. Although a technique considered to be the gold standard was not used, other studies have already demonstrated the validity of both the anthropometric technique based on skin fold measurement[31,32] and

Table II
Comparison of two instruments for the measurement of body fat: adipometer and bioimpedance

General comparison (n = 32)	*p value*
	0.3929
Group comparison	*p value*
PG (n = 9)	0.1347
AG (n = 10)	0.5251

the BIA technique[33,34] compared to DXA and to doubly-labeled water, which are considered to be the gold standards. On the basis of this premise, the statement would be correct if it were not a special group of patients using PNT, which influences the hydration state since, according to its own definition, PN is an intravenous infusion of fluids and nutrients[35].

Table I presents the results discussed above. PG patients showed significantly higher mean percent lean mass values compared to AG and CG. Lean mass is a compartment known to vary positively with hydration status[36]. Thus, the lean mass value is overestimated in hperhydrated individuals[37], representing a limitation of the use of this type of instrument[36]. On this basis, BIA does not seem to be a good instrument for the assessment of body composition for patients with SBS who use PNT. However, BIA continues to be a technique of promising future and requires more studies, especially regarding the development of specific equations for different populations and the investigation of their basic assumptions in order to minimize their limitations. The skin fold technique has proved to be a good option for more reliable estimates of body composition.

Conclusion

- Time since first intestinal resection, remaining intestine and preservation of the ileocecal valve are some of the more relevant aspects for the maintenance of nutritional status in individuals with SBS.
- Large resections, as well as the resected portions and the hypothesis of the existence of an inflammatory state related to the long-term use of PNT, explain the greater nutritional impairment of PG compared to AG and CG, although no significant difference in food consumption was detected between these three groups.
- Since the use of PNT can lead to a state of hyperhydration, the results of BIA should be interpreted with caution, in view of the fact that the lean mass determined by this method varies positively with the hydration state of an individual.

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