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Increased Adiposity and Reduced Lean Body Mass in Patients with Short Bowel Syndrome

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Abstract

Background: Few studies have examined the metabolic consequences of short bowel syndrome (SBS) and its effects on body composition in adults. We hypothesized that body composition of SBS patients is altered compared to a normal age, race, and sex-matched population, regardless of parenteral nutrition (PN) dependence.

Aim: To compare the body composition of adult patients with SBS to age, sex and race matched healthy controls.

Methods: Twenty patients with SBS underwent body composition analysis using the GE Lunar iDXA scanner. Patients were age, sex and race matched to controls from the National Health and Nutrition Examination Survey (1999–2004). Mean differences in body mass index, fat free mass, fat mass, percent body fat, visceral adipose tissue mass and volume, and bone mineral density were measured. Statistical analysis was performed using SAS 9.4 software.

Results: Fifty-five percent of subjects had a history of PN use and 30% were current PN users. Mean percent body fat for SBS patients was 35.1% compared to 30.9% for healthy controls ($p=0.043$). Fat free mass was reduced in SBS ($p=0.007$). Patients with reduced bone mass had a

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trend towards significantly more years of PN exposure compared to those with normal bone mass ($p=0.0094$), and a trend towards older age ($p=0.075$).

Conclusions: SBS is associated with increased percent body fat and reduced fat free mass, suggesting that improved dietary and therapeutic interventions are needed to restore normal metabolic indices and avoid risk for metabolic syndrome in SBS patients.

Keywords

Short bowel syndrome; body composition; parenteral nutrition; intra-abdominal fat; body mass index

INTRODUCTION

The prevalence of short bowel syndrome (SBS) is difficult to assess due to varying definitions and multiple diverse etiologies, but present estimates suggest that 10,000–20,000 people have SBS and are treated with parenteral nutrition per year in the United States [1]. Intestinal adaptation occurs over a period of approximately 2 years after intestinal resection and is characterized by physiological and hormonal changes that ultimately result in modification of the absorptive capacity of the intestine. Crypt cell proliferation is stimulated in the remnant gut with the end result of enhanced villus height, increased crypt depth and increased nutrient and electrolyte absorptive capacity [2],[3].

In mouse models of SBS, intestinal resection results in increased total body adiposity and decreased lean muscle mass with evidence of metabolic syndrome [4],[5],[6]. While initial weight loss following resection was reversed and weight returned to baseline, mice with SBS had altered body composition, with preferentially increased body fat stores compared to lean body mass [5]. By contrast, the effects of loss of small bowel surface area on body composition in humans is less well described. In pediatric patients with intestinal failure receiving long-term parenteral nutrition, higher fat mass, greater body mass index (BMI), and decreased lean mass were observed in patients on total and partial parenteral nutrition (PN) compared to those not receiving PN [7]. In another series of pediatric SBS patients, linear growth (surrogate for lean body mass) was lower and correlated with greater PN requirements [8].

In adults with SBS, there are limited data evaluating body composition. A few studies used bioelectric impedance analysis (BIA) but were primarily focused on comparing the BIA and dual-energy x-ray absorptiometry (DXA) methods and validating the BIA method for measuring total body water and fat free mass in patients with SBS [9],[10]. These studies did not evaluate possible differences between SBS patients and normal, healthy controls. A study from Denmark measured DXAs in SBS PN dependent patients over a period of 30 months and found that patients had a low but normal average BMI (21.18) with no change in fat mass, fat free mass, or total body mineral content. This study did not include normal age and sex matched controls so body composition in SBS patients was not directly compared to normal patients [11]. More recently, another study from Denmark examined the prevalence of sarcopenia in patients with intestinal insufficiency (SBS patients fed orally) compared to those with intestinal failure (SBS patients requiring parenteral nutrition) and found that both

groups had an increased risk for sarcopenia. The prevalence of sarcopenia was significantly higher in the intestinal failure patient group (72% vs. 34%). Although BMI, fat mass and fat free mass were lower in female intestinal failure patients, these parameters were not compared to normal controls and visceral fat mass was not evaluated [12].

Overall body composition in adults and children in the United States has previously been described in the National Health and Nutrition Examination Survey (NHANES). This program began in the 1960s and was conducted as a series of surveys before becoming a continuous program in 1999[13]. From 1999 to 2006, DXA was used for anthropomorphic body composition analyses including measurement of BMI, total body fat free mass (FFM), and total body fat mass (FM).

The aim of our study was to address the hypothesis that there are long term metabolic consequences of SBS by comparing body composition of patients with SBS receiving PN or a strictly enteral diet to an age, sex, and race matched healthy adult population in the United States.

METHODS

Patient Selection

This study was approved by the Human Studies Institutional Review Board at Washington University School of Medicine, where all study procedures took place. All study conduct was in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments. Patients age 21 and older with an established diagnosis of SBS were prospectively recruited for study participation at the Washington University School of Medicine Short Bowel Syndrome Clinic. SBS was defined as less than or equal to 200cm of remaining bowel (n=17) or evidence of functional short bowel syndrome based on need for PN or the presence of associated nutritional deficiencies (n=3). Patients with or without a history of PN use were included in the study. Patients were excluded from the study if they had active Crohn's disease or a history of prior small bowel transplantation.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Study procedures

At the time of study enrollment, patients underwent body composition analysis using the GE Lunar iDXA scanner (GE Healthcare, Chicago, Illinois). BMI, FFM, FM, percent body fat (%BF), visceral adipose fat mass (VFM), visceral adipose fat volume (VFFV), total bone mineral density (BMD), T-score, and Z-score were recorded. Chart review at the time of the iDXA scan was performed to obtain age, race, sex, smoking status, duration of SBS, etiology of SBS, length of remaining small bowel, presence of a colon in continuity with the remaining small bowel, history of PN, dates of PN use, type of anastomosis or ostomy, and history of teduglutide treatment. Duration of PN use was calculated using the recorded start and stop dates or the date of the iDXA scan for current PN users.

Data from the NHANES from 1999–2004 cohort were used as the reference standard for normal, healthy controls in the general population [14]. Patients were matched to age, sex, and race controls from the NHANES data in order to measure the mean difference in BMI, FFM, FM, and %BF.

To determine whether differences in calorie intake or the nutritional content (% fat vs carbohydrate vs protein) could explain the body composition differences in our patients, 48-hour written diet diaries were analyzed for nutritional composition using the Nutrition Data System for Research (NDSR) software (University of Minnesota Nutrition Coordinating Center). Based on the values obtained using the NDSR software, the mean caloric intake, mean percent calories from fat, and mean percent calories from carbohydrate over a 48-hour period were calculated.

Statistical Analysis

The mean, standard deviation and range were reported for all demographic parameters. Paired t-test was used to determine the significance of the mean difference between our patient population and the NHANES reference standard. Two-sample t-test was used to compare the mean values for BMI, FFM, FM, %BF, VFM, VFV, BMD, T-score and Z-score between various subgroups as part of additional sub-analyses performed for this study. Kruskal-Wallis test was used to compare body composition among current PN, former PN and never PN users. Pearson correlations were estimated to determine the linear relationship between length of remaining small bowel to BMI, FFM, FM, and VFM as well as the correlation between duration of PN to BMI, FFM, FM, and VFM. Pearson correlation matrices were also estimated to determine the linear relationship between mean percent fat calories consumed to BMI and mean fat mass, mean percent carbohydrate calories consumed to mean BMI and mean fat mass, highest individual BMI value with their calories consumed, highest individual BMI value with their fat grams consumed, and highest individual fat mass and their calorie intake. Analysis of covariance was performed to correct for age and gender impact on FFM and FM. All statistical tests were two-sided and performed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Demographic data

Twenty patients who met inclusion criteria were included in this study (Supplemental table 1). There were 9 males and 11 females. The majority of patients were of Caucasian descent (n=19). The etiology of short bowel included Crohn's disease (n=10), radiation enteritis requiring resection (n=1), small bowel obstruction or tumor requiring resection (n=7), and ischemic bowel requiring resection (n=2). Eleven patients had at least part of the colon in continuity with the remaining small bowel. Eleven patients had a history of PN of whom 6 patients were actively using PN at the time of study enrollment. Three patients were treated with teduglutide at the time of the study.

Mean values were calculated for all demographic parameters of interest (Table 1). Age at the time of iDXA was 53.9 years. Duration of PN prior to study enrollment was 5.8 years. The

length of remaining small bowel was 124.3 cm. Duration of short bowel syndrome was 11.9 years. BMI was 25.5 and % body fat was 35.11. Fat-free mass was 44885.75 grams and fat mass was 23403.15 grams. Visceral fat mass was 786.5 grams and visceral fat volume was 833.9 cm³. Bone mineral density was 1.093 g/cm² with corresponding T-score of -0.4 and Z-score of 0.04.

SBS patients have reduced fat free mass and higher percent body fat compared to normal age, gender and raced matched controls

Compared to the NHANES reference standard, patients with SBS had a lower fat free mass (Table 2; mean difference -5.93, $p=0.007$). SBS patients also had a higher percent body fat compared to the NHANES reference standard (mean difference +4.49, $p=0.043$). There was no difference in FM (mean difference -0.21, $p=0.915$) or BMI (mean difference -1.31, $p=0.299$).

There was no significant correlation between duration of SBS and FM ($R=-0.268$, $p=0.253$, FFM ($R=0.038$, $p=0.874$), or VFM ($R=-0.259$, $p=0.269$); (Supplemental Figure 1). There was no significant correlation between the length of remaining small bowel and FM ($R=0.058$, $p=0.818$), FFM ($R=-0.335$, $p=0.175$) or VFM ($R=-0.034$, $p=0.895$), and no significant correlation between duration of PN and FM ($R=-0.329$, $p=0.212$, FFM ($R=-0.154$, $p=0.571$), or VFM ($R=-0.071$, $p=0.793$).

To examine age and gender impact on FM and FFM, analysis of covariance was performed, showing that age is not a significant predictor of FM after adjusting for gender, and gender is not a significant predictor of FM after adjusting for age. However, although age is not a significant predictor of FFM after adjusting for gender, gender is a significant predictor of FFM after adjusting for age, with males having significantly higher mean FFM compared to females, $p=0.0001$, (female FFM=38,134 g with 95% CI (33817, 42450) and male FM = 53,138 g with 95% CI (48363, 57913).

Short bowel syndrome and bone mass

Forty percent of SBS patients had low bone mass (osteopenia or osteoporosis; T-scores of -1 or lower, Table 3). We observed a trend towards a longer duration of PN treatment in patients with low bone mass compared to those with normal bone mass (11.58 years [SD 10.85] vs 2.39 [SD 3.52], $p=0.094$; Table 3). Patients with low bone mass also showed a trend toward older age (61.4 years vs 48.9 years; $p=0.075$).

Effects of PN use on body composition

Several secondary analyses were also performed. Patients without a history of PN use were compared to those with a prior history of PN use and those currently using PN (Table 4) to assess whether PN use might provide additional risk for increasing the percent of body fat and reducing fat free mass. Although there was no significant difference in BMI ($p=0.114$), there were significant increases in FM with the highest mass in former PN > current PN users and both with higher FM compared to never PN users ($p=0.026$). There was a trend toward a significant difference in %BF ($p=0.057$) with former > current PN users and both having higher %BF compared to never PN users. We also observed a significant difference

in VFM with the highest mass observed in the former PN users > current PN users and both were higher than in never PN users ($p=0.025$). Similarly, a significant difference in VFV was observed, again with former PN users having higher VFV than current PN users, and both higher than non-PN users and ($p=0.025$). There was no significant difference in FFM ($p=0.796$). There was no significant difference in BMD ($p=0.707$), T-score ($p=0.497$), or Z-score ($p=0.45$).

Body composition analyses in SBS patients with Crohn's disease compared to SBS patients without Crohn's disease

To rule out an effect of Crohn's disease on body composition differences among SBS patients, we compared patients with SBS due to Crohn's disease to patients with SBS from all other etiologies (Table 5). No statistically significant difference was seen in BMI ($p=0.467$) or %BF ($p=0.187$). There was no significant difference in FFM ($p=0.521$) or FM ($p=0.372$). However, there was a trend towards a difference in VFM ($p=0.053$) and VFV ($p=0.054$) with Crohn's disease patients having a greater mean VFM and mean VFV compared to non-Crohn's disease patients. Those trends are consistent with studies showing an increase in visceral adiposity in Crohn's disease compared to normal patients [15],[16]. No significant difference was seen in total BMD ($p=0.417$), T-score ($p=0.533$), or Z-score ($p=0.691$).

The presence of a colon in continuity does not affect body composition in SBS patients

When comparing SBS patients with colon in continuity to those without, no statistically significant differences were seen in BMI ($p=0.324$), %BF ($p=0.343$), FFM ($p=0.374$), FM ($p=0.804$), VFM ($p=0.725$), or VFV ($p=0.726$) (Supplemental Table 2). No significant difference was seen in total BMD ($p=0.417$), T-score ($p=0.533$), or Z-score ($p=0.691$). Thus, the presence of a colon did not affect BMI or body composition, despite its role in absorbing additional calories as short chain fatty acids generated by the colonic microflora from malabsorbed carbohydrates [17].

Body composition in SBS patients is independent of calorie consumption

Sixteen patients (10 former TPN users, 4 current TPN users, 2 with no history of TPN) who had completed written food diaries at the time of the iDXA were included in this sub-analysis. The mean 48-hour caloric intake was 2845 kcal (SD 1064, range 1052–5006), the mean 48-hour fat gram intake was 123 grams (SD 56.3, range 47.1–242.1), the mean percent calories from fat was 28.1% (SD 8.2, range 19.4–52.1), and the mean percent calories from carbohydrates was 44% (SD 10.6, range 29.3–67.6).

There was no significant linear correlation between mean percent fat calories consumed and BMI ($R=0.114$, $p=0.673$) or fat mass ($R=0.279$, $p=0.296$; Supplemental Figure 2). There was also no significant linear correlation between mean percent carbohydrate calories consumed and BMI ($R=-0.332$, $p=0.209$) or fat mass ($R=-0.469$, $p=0.067$), and no significant linear correlation between total caloric intake and BMI ($R=0.233$, $p=0.386$) or fat mass ($R=0.089$, $p=0.744$). For the patient with the highest BMI (42.3 kg/m^2), there was no significant linear correlation between BMI and mean 48-hour caloric intake ($R=0.071$, $p=0.794$) or 48-hour fat intake ($R=0.135$, $p=0.618$). For the patient with the highest fat mass

(46709g), there was no significant linear correlation with mean 48-hour caloric intake ($R=0.098$, $p=0.719$) or mean fat intake ($R=0.191$, $p=0.479$).

Three patients were on teduglutide at the time of the study. Two of these had Crohn's disease as the etiology for their short bowel syndrome. Compared to non-teduglutide users with Crohn's, there was no statistical difference in BMI, %BF, fat-free mass, fat mass, visceral adipose fat mass, visceral adipose fat volume, or bone mineral density. Although teduglutide did not influence body composition, particularly in patients with Crohn's disease, we recognize the limitations of the small sample size in making any firm conclusions from these data.

DISCUSSION

Herein we show that patients with SBS exhibit different body composition compared to a healthy population, with reduced fat free mass and a higher percentage of body fat. In contrast to the few published studies of body composition in SBS adults, our data suggest that use of PN significantly impacts body composition with respect to fat mass, visceral fat mass and visceral fat volume as well as body fat percentage. The etiology of SBS likely plays a role in body composition changes in response to PN. For example, IBD patients trended towards increased visceral adipose fat compared to those with SBS from other etiologies.

The physiologic changes that occur with PN administration in patients who are restricted from oral intake appear to overlap with some of the changes that occur after starvation and refeeding. Following temporary food restriction, refed mice were found to have increased intra-abdominal fat accumulation as well as decreased peripheral insulin sensitivity [18]. Studies in adult patients recovering from anorexia nervosa or starvation have demonstrated that after achieving a normal body weight in the recovery period, total body protein recovery is incomplete and body mass is primarily recovered as fat in a visceral predominant distribution [19],[20],[21],[22]. Our results are concordant with these findings in that current and former PN patients demonstrated a marked increase in visceral adipose fat mass compared to patients who had never received PN. This suggests that refeeding patients with SBS, particularly with PN, results in a preferential increase in visceral adipose fat.

Physical activity and exercise play well-recognized roles in regulating body composition, independent of calorie intake [23],[24],[25],[26],[27]. Although we have not quantified physical activity in our patients, this likely plays a significant role in regulating body composition in PN-dependent SBS patients, who are at risk for reduced physical activity due to reduced mobility during infusion time and symptoms of fatigue, which are common in this patient cohort [28].

DXA has been shown to be an accurate means of assessing body fat in malnourished Crohn's disease patients [29]. Analysis of body composition using DXA in patients with Crohn's disease and a history of intestinal resection, including both colonic and small bowel resection, who were not PN users showed significant loss of fat free mass. There was relative preservation of fat mass, thus when expressed as a percentage of overall body weight, fat

mass was significantly increased [30]. As has been previously described, visceral adipose fat increased in pediatric and adult Crohn's disease patients and in adults was associated with the stricturing phenotype [15],[16]. While our study did not show a significant difference in fat mass between SBS patients with and without Crohn's disease, Crohn's patients showed a trend towards having a greater visceral adipose fat mass. For these patients, it is possible that our findings reflect fibrostenotic or other complications of the underlying Crohn's disease that resulted in SBS, rather than simply the presence of SBS. Four of the Crohn's disease patients with SBS had received multiple biologic agents, suggesting a history of more severe inflammatory disease, but the use of biologic agents did not correlate with worse T-scores. However, our limited sample size is insufficient to elucidate a correlation between use of biologics and BMD, but this certainly merits further study.

Visceral adipose tissue (VAT) is located primarily around the major intra-abdominal organs, such as the liver and intestines, and plays an important role in metabolic homeostasis via secreted pro-inflammatory mediators and cytokines that drain into the portal circulation [31]. Visceral adipose fat has been linked to increased risk of cardiovascular disease, mortality, and metabolic syndrome [32],[33],[34],[35]. One study examining VAT in obese (BMI 30–49.9) Caucasian and African American women using the GE Lunar iDXA scanner identified a greater than 50% probability of developing metabolic syndrome with a VAT volume 1713cm² in Caucasian women and a VAT volume 1320 cm² in African American women [34]. Although the majority of patients in our study did not approach these values, three Caucasian patients in our study had VAT volumes approaching or exceeding these values, two of whom were former PN users and one was a current PN user. Providers who care for SBS patients should be aware of the consequences of increased VAT and the risk of cardiovascular disease. Closer monitoring of lipid profiles and screening for metabolic syndrome diagnostic criteria should be encouraged in SBS patients, particularly in those patients who are currently on or have a history of PN use.

The presence of colon in continuity with the remaining small bowel is a key part of the small bowel adaptation response. In addition to its importance in fluid and electrolyte absorption, the colon is able to provide additional calories by absorption of dietary medium chain triglycerides as well as short chain fatty acids produced by gut bacteria from malabsorbed complex carbohydrates [36]. Our results did not show any significant difference in BMI or body composition between those SBS patients with a colon in continuity and those without. This suggests that while the colon may play a role in scavenging calories for overall nutrition, there is no significant impact on body composition as a result of this activity.

A potential limitation to using of DXA for body composition analysis is the underlying assumption that hydration of the fat free mass remains constant. However, this can be affected by factors such as fluid loss in the setting of high ostomy output or diarrhea, oral hydration intake, and use of intravenous fluids [9]. Patients in our study who underwent DXA scans were clinically stable with well controlled stool output and on stable PN regimens. As such, the patients in this study can be considered to have stable fluid homeostasis and the results of our study reflect the most accurate assessment of their body composition.

Teduglutide has been approved for therapy of PN or IV fluid dependent SBS patients. Only three of our patients were on teduglutide at the time of the study. Two of these had Crohn's disease. Compared to non-teduglutide users with Crohn's, there was no significant difference in BMI, % body fat, fat-free mass, fat mass, visceral adipose fat mass, visceral adipose fat volume, or bone mineral density, but the number of patients is too limited to draw any specific conclusions.

Long term studies with a larger patient population are needed to better determine the impact of SBS on body composition. Results from our study suggest that PN use even after cessation may have long term metabolic consequences (Tables 2 and 4) and further study of body composition and visceral adipose tissue in these patients may help to guide clinicians when counseling these patients about dietary intake and mitigating cardiovascular risk. Improved PN management has resulted in long term survival of PN dependent patients [37], thus continuous evaluation of PN composition for patients with long term dependency may be warranted to avoid precipitating metabolic syndrome. SBS appears to alter body composition independent of dietary intake and shifting the focus towards body composition rather than regaining a normal BMI and body weight will have long-term benefits for managing this challenging group of patients. Future prospective analyses will allow us to study changes in body composition over time, particularly in those patients who remain on PN.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

SBS	Short bowel Syndrome
PN	Parenteral nutrition
NHANES	National Health and Nutrition Examination Survey
DXA	Dual-energy x-ray absorptiometry

BIA	Bioelectric impedance analysis
FFM	Fat free mass
FM	Fat mass
%BF	% body fat
VFM	Visceral adipose fat mass
VFV	Visceral adipose fat volume
BMD	Bone mineral density
NDSR	Nutrition Data System Research
VAT	Visceral adipose tissue

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Table 1

Mean values for SBS patients; (i) demographic data including age, duration of illness, duration of TPN therapy and length of remaining small bowel and (ii) body composition analyses.

	Mean (SD)	Median (IQR)	Range	
			Minimum	Maximum
Age (years)	53.9 (16.14)	55 (28.5)	22	76
Duration of SBS (years)	11.89 (13.25)	6 (13.5)	6	49
Duration of TPN (years)	5.84 (8.23)	1.67 (2938.5)	0.33	27.51
Length of small bowel (cm)	124.28 (40.03)	125 (60)	60	240
BMI	25.5 (5.44)	24.5 (3.4)	19.3	42.3
Percent body fat	35.12 (9.94)	38.5 (9.3)	9.7	52.3
Fat free mass (grams)	44885.75 (10148.04)	43567.5 (11354)	30770	69347
Fat mass (grams)	23403.15 (8316.14)	24326 (5403)	5696	46709
Visceral adipose fat mass (grams)	786.5 (627.45)	727.5 (725)	60	2312
Visceral adipose fat volume (cm ³)	833.9 (665.04)	771 (768)	64	2451
Total bone mineral density (g/cm ²)	1.09 (0.19)	1.09 (0.22)	0.73	1.51
T-score	-0.4 (1.59)	-0.55 (1.85)	-3.4	3.2
Z-score	0.04 (1.4)	-0.3 (1.25)	-2	3.2

Table 2:

SBS patient body composition parameters compared to age and gender matched NHANES controls (paired T-test, SAS v.9.4).

	Mean	SD		Mean difference from NHANES	SD	p-value
BMI	25.5	5.44		-1.31	5.46	0.299
Percent body fat	35.11	9.94		4.49	9.26	0.043
Fat free mass (grams)	44885.75	10148.04		-5.93	8.74	0.007
Fat mass (grams)	23403.15	8316.14		-0.21	8.57	0.915

Table 3:

Comparison of demographic factors in SBS patients with normal or low bone density. Patients with low bone density tended to have a longer duration of PN use compared to patients with normal bone density.

	Normal bone density (n=12)				Low bone density (n=8)				p-value
	Number	Mean (SD)	Median (IQR)	Range	Number	Mean (SD)	Median (IQR)	Range	
Age	--	48.92 (16.72)	48.5 (29)	22 – 73	--	61.38 (12.68)	63 (22)	43 – 76	0.075
Female	5	--	--	--	6	--	--	--	0.142
Tobacco users	6	--	--	--	5	--	--	--	0.582
Years of short bowel syndrome	--	13.98 (16.29)	5.5 (22)	0.75 – 49	--	8.75 (6.36)	8 (10.5)	1 – 18	0.332
Centimeters of remaining small bowel	--	123.82 (56.61)	120 (72)	60 – 240	--	125 (30.41)	130 (50)	70 – 150	0.954
BMI	--	25.49 (4.35)	24.8 (4.25)	20.1 – 36.3	--	25.51 (7.12)	24.2 (3.15)	19.3 – 42.3	0.994
History of parenteral nutrition use	10	--	--	--	7	--	--	--	0.798
Years of parenteral nutrition	--	2.39 (3.52)	0.92 (1.47)	0.33 – 12.06	--	11.58 (10.85)	9.16 (19.39)	1.04 – 27.51	0.094
Tedugluti de use	3	--	--	--	0	--	--	--	0.125

Table 4:

Comparison of SBS patients' PN status (former, current or never PN therapy) reveals differences in fat mass ($p=0.026$), visceral adipose fat mass ($p=0.025$) and visceral adipose fat volume ($p=0.025$).

	Former PN (n=11)		Never PN (n=3)		Current PN (n=6)		p-value
	Mean	SD	Mean	SD	Mean	SD	
BMI	26	3.872	21.367	1.939	26.65	8.288	0.114
Percent body fat	39.255	7.021	21.467	15.105	34.35	5.9782	0.057
Fat free mass (grams)	44218.18	10864.3	45943.33	10142.71	45580.83	10577.68	0.796
Fat mass (grams)	27091.18	6902.29	11865.33	8450.37	22410.67	5289.28	0.026
Visceral adipose fat mass (grams)	921	554.483	78.667	25.716	893.8333	725.679	0.025
Visceral adipose fat volume (cm³)	976.455	587.682	83.667	25.652	947.667	769.224	0.025
Total bone mineral density (g/cm²)	1.064	0.137	1.102	0.252	1.144	0.279	0.707
T-score	-0.709	1.122	-0.167	1.943	0.05	2.262	0.497
Z-score	-0.209	1.239	0.233	1.012	0.633	1.836	0.45

Table 5:

Comparison of body composition parameters in patients with SBS from Crohn's disease versus SBS from all other causes. A trend towards increased visceral adipose fat mass and visceral fat volume was found in Crohn's disease patients with SBS compared to SBS from other etiologies.

	Crohn's disease (n=10)		Non-Crohn's disease (n=10)		p-value
	Mean	SD	Mean	SD	
BMI	24.57	1.88	26.43	7.55	0.467
Percent body fat	38.16	4.71	32.07	12.879	0.187
Fat free mass (grams)	43368.9	7298.13	46402.6	12610.8	0.521
Fat mass (grams)	25147.1	2714.66	21659.2	11483.59	0.372
Visceral adipose fat mass (grams)	1054.7	540.929	518.3	615.361	0.053
Visceral adipose fat volume (cm³)	1118	573.632	549.8	652.147	0.054
Total bone mineral density (g/cm²)	1.102	0.165	1.085	0.232	0.849
T-score	-0.5	1.288	-0.3	1.915	0.788
Z-score	-0.08	1.268	0.16	1.581	0.713