RBCDH Brazilian Journal of KINANTHROPOMETRY and Human Performance

DOI: http://dx.doi.org/10.5007/1980-0037.2013v15n6p686

original article

Effects of bariatric surgery on the body composition of adults

Efeitos da cirurgia bariátrica na composição corporal de adultos

Tiago Wally Hartwig[1,4]
Félix Antônio Insaurriaga dos Santos[2]
Maria Cristina González[3]
Airton José Rombaldi[1,4]

Abstract – The prevalence of obese individuals has increased worldwide in recent years. The most alarming cases are known as morbidly obese. An effective method to change the anthropometric characteristics of this population with excess body weight and high fat mass is bariatric surgery. The objective of this study was to analyze the body composition of morbidly obese patients undergoing bariatric surgery in the city of Pelotas, southern Brazil. In a prospective cohort study, a group of morbidly obese patients was followed up 30 days before and 30 days after surgery. The sample consisted of 123 patients who underwent vertical banded Roux-en-Y gastroplasty between April 2003 and May 2010. Body composition (fat percentage) was determined by bioelectrical impedance analysis. The mean age of the patients was 36.1 ± 8.8 years and mean body weight loss was 14.1 ± 6.0 kg ($p<0.001$). The mean reduction in body mass index (BMI) was 5.2 ± 2.1 kg/m^2 ($p<0.001$). Body fat percentage and fat mass were reduced by 2.8% ($p<0.001$) and 9.7 ± 4.9 kg ($p<0.001$), respectively. In addition, there was a reduction of 4.4 ± 3.4 kg ($p<0.001$) in lean mass. We concluded that the surgical procedure significantly reduced body weight, BMI, fat percentage and fat mass and is an alternative when conventional treatments appear ineffective.

Key words: Adults; Bariatric surgery; Body composition; Morbid obesity.

Resumo – *Os últimos anos destacam-se por uma alta prevalência de indivíduos obesos no âmbito mundial, sendo os casos mais alarmantes conhecidos como obesos mórbidos. Um método efetivo para alterar as características antropométricas desse público com excesso de peso e elevada massa gorda é a cirurgia bariátrica. O estudo teve como objetivo analisar as alterações na composição corporal de pacientes obesos mórbidos submetidos à cirurgia bariátrica na cidade de Pelotas, RS. O estudo se caracterizou por ser uma coorte prospectiva, acompanhando um grupo de obesos mórbidos 30 dias antes e 30 dias após a cirurgia. A amostra foi composta por 123 pacientes, submetidos à Gastroplastia Vertical em Y-Roux no período de abril de 2003 a maio de 2010. A composição corporal (percentual de gordura) foi determinada através de bioimpedância elétrica. A média de idade foi de 36,1 ± 8,8 anos. A perda de massa corporal média da amostra foi de 14,kg ± 6,0 ($p<0,001$) e a média de redução do índice de massa corporal (IMC) foi de 5,2 kg/m^2 ± 2,1 ($p<0,001$). Em relação às variáveis percentual de gordura e massa gorda, houve redução de 2,8% ($p<0,001$) e 9,7 kg ± 4,9 ($p<0,001$), respectivamente, ocorrendo, também, uma perda de 4,4 kg ± 3,4 ($p<0,001$) na massa magra. Concluiu-se que o procedimento cirúrgico implicou reduções significativas na massa corporal, no IMC, no percentual de gordura e na massa gorda, sendo uma alternativa a ser considerada quando as formas convencionais de tratamento se mostrarem pouco eficazes.*

Palavras-chave: *Adultos; Composição corporal; Cirurgia bariátrica; Obesidade mórbida.*

1 Universidade Federal de Pelotas. Programa de Pós-Graduação em Educação Física. Pelotas, RS. Brasil.

2 Médico e Especialista em Cirurgia Videolaparoscópica. Membro da Sociedade Brasileira de Cirurgia Bariátrica e Metabólica. Pelotas, RS. Brasil

3 Universidade Católica de Pelotas. Programa de Pós-Graduação em Saúde e Comportamento. Pelotas, RS. Brasil.

4 Universidade Federal de Pelotas. Grupo de Estudos em Epidemiologia da Atividade Física. Pelotas, RS. Brasil.

Received: 17 March 2013
Accepted: 16 May 2013

INTRODUCTION

Obesity has been a worldwide concern since the mid-1990s and its prevalence is increasing at an alarming rate[1]. According to the World Health Organization[2], there are more than 300 million obese people in the world. In Brazil, data from the Ministry of Health [Household Budget Survey (POF 2008-2009)[3] and Telephone-Based Surveillance of Risk and Protective Factors for Chronic Diseases (VIGITEL)[4]] indicated a prevalence of obesity of 14.5% and 16% in the adult population, respectively. Estimates show that in 2025, Brazil will be the fifth country to have problems of obesity[2].

Obesity is characterized by excessive accumulation of body fat as a consequence of a positive energy balance[5,6]. The most alarming cases are classified as morbidly obese (grade 3 obesity) based on a body mass index (BMI) of 40.0 kg/m² or higher[2]. Morbid obesity is frequently associated with comorbidities such as cardiovascular diseases, certain types of cancer, and diabetes[7].

Conventional first-line treatments for obesity include diet, physical activity, and pharmacological intervention. However, the results obtained for grade 3 obese patients indicate that these treatments are poorly effective, since in more than 90% of cases the patients seem to be unable to achieve and maintain a body weight loss of 5 to 10% over a period of 5 years[8,9]. In this respect, bariatric surgery has been shown to be an effective method for the treatment of morbidly obese subjects. Surgical treatment is indicated because of the lack of effectiveness of non-surgical methods and because the mortality risk of untreated morbid obesity is high[10]. It is well established in the literature that bariatric surgery increases longevity and improves the quality of life of morbidly obese patients through better control of comorbidities[11,12].

The benefits of bariatric surgery in terms of body fat mass reduction, improvement of comorbidities, and BMI reduction have been recognized[13-15]. However, most studies followed up patients after surgery over periods of 6 months or more[14,15], whereas reports evaluating the short-term postoperative changes in body composition induced by bariatric surgery are rare, especially in Brazil. Therefore, the objective of the present study was to analyze the body composition of morbidly obese patients undergoing bariatric surgery in the city of Pelotas, southern Brazil, 30 days after the surgical procedure.

METHODOLOGICAL PROCEDURES

A prospective cohort study was conducted in which the same group was compared 30 days before and 30 days after surgery. The sample of convenience consisted of 123 morbidly obese (grade 3 obesity or BMI ≥ 40 kg/m²) patients who underwent vertical banded Roux-en-Y gastroplasty with or without gastrostomy (Fobi-Capella surgery) between April 2003 and May 2010. The patients were submitted to anthropometric assessment and evaluation of body composition.

For anthropometric assessment, body weight was measured with a Filizola platform digital scale (Model PL, capacity of 300 kg) to the nearest 0.1 kg. The weight was measured with the subject standing barefoot with the back against the scale and wearing light clothing. Height was measured to the nearest 0.1 cm with a 200-cm metal stadiometer coupled to the scale according to a standardized method[16]. The subject was asked to stand with the back against the stadiometer and to take a deep breath. The variables were treated as continuous.

The BMI was calculated as body weight (kg)/height (m^2). The cut-off value proposed by the World Health Organization was used for the classification of nutritional status[2]. Subjects with a BMI ≥ 40 kg/m^2 were classified as morbidly obese.

Body composition (percentage of body fat and lean body mass) was determined by bioelectrical impedance analysis using a Quantum analyzer (RJL Systems®), with a frequency of 50 kHz, according to a standardized technique[17]. The absolute and relative values of lean body mass, body water and body fat were obtained for each patient in the two assessments, considering the lowest value of three measurements of resistance and reactance (implemented in the Compcorp® software).

Demographic data including gender, skin color and age were obtained by patient self-report and categorized as follows: gender = male and female; skin color = white and black/mulatto; age = up to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, and > 50 years.

The results were entered into Microsoft Excel spreadsheets, analyzed for errors, and then imported into the Stata 10.0 statistical program. For continuous variables, the results are expressed as the mean ± standard deviation. The Shapiro-Wilk test was used to determine whether the data showed a normal distribution. Differences between means were evaluated by the Student *t*-test for paired samples. For categorical variables, the results are reported as proportions and differences were evaluated by Fisher's exact test. The accepted level of significance was $p<0.05$.

The study protocol was approved by the Ethics Committee of Escola Superior de Educação Física, Universidade Federal de Pelotas (Permit No. 12553013.4.0000.5313). The data were collected after the subjects had signed the free informed consent form.

RESULTS

The sample consisted of 123 patients, including 94 (76.5%) women, and the mean age was 36.1 ± 8.8 years. Table 1 shows the distribution of the sample according to age and gender. The 31-40 year age group was the most frequent among men and most women were in the 21-30 and 41-50 year age groups.

The mean preoperative body weight of the sample was 125.5 ± 25.2 kg (range: 87.9 to 258.0 kg). After surgery, the mean body weight was 111.4 ± 22.8 kg (range: 76.4 to 226.2 kg) ($p<0.001$). The mean weight loss (relative and absolute values) was 11.2% and 14.1 ± 6.0 kg, respectively ($p<0.001$).

Table 1. Distribution of the sample according to age and gender (n=123).

Age (years)	Gender			
	Male		Female	
	N	%	N	%
Up to 20	0	0.0	2	2.2
21 – 30	11	37.9	29	30.8
31 – 40	13	44.9	28	29.8
41 – 50	3	10.3	29	30.8
> 50	2	6.9	6	6.4
Total	29	100.0	94	100.0

With respect to skin color, most of the patients undergoing bariatric surgery (92.7%) reported to be white; of these, 70.7% were women.

Table 2 shows the body weight loss of the subjects according to age. Most patients undergoing bariatric surgery were between 21 and 40 years of age. In addition, analysis of the weight loss categories according to age showed that in the 21-30 year age group, most patients (52.5%) lost between 10 and 14.9 kg. In contrast, in the 31-40 year age group, most subjects (53.8%) lost between 10 and 19.9 kg.

The body weight loss of the subjects according to gender is shown Table 3. The range of 10 to 14.9 kg was de most frequent weight loss category among men (27.6%) and women (49.0%).

Table 2. Body weight loss of the subjects according to age (n=123).

Body weight loss (kg)	Age (years)					
	< 20 n (%)	21 - 30 n (%)	31 - 40 n (%)	41 - 50 n (%)	>50 n (%)	Total n (%)
Up to 4.9	-	1 (2.5)	4 (9.8)	-	-	5 (4.0)
5.0 to 9.9	1 (50.0)	5 (12.5)	6 (14.6)	6 (18.7)	2 (25.0)	20 (16.3)
10.0 to 14.9	1 (50.0)	21 (52.5)	11 (26.9)	15 (46.9)	6 (75.0)	54 (43.9)
15.0 to 19.9	-	6 (15.0)	11 (26.9)	6 (18.7)	-	23 (18.7)
20.0 to 24.9	-	2 (5.0)	7 (17.0)	3 (9.4)	-	12 (9.8)
> 25.0	-	5 (12.5)	2 (4.8)	2 (6.2)	-	9 (7.3)
Total	2 (100.0)	40 (100.0)	41 (100.0)	32 (100.0)	8 (100.0)	123 (100.0)

The mean BMI was reduced from 46.1 ± 7.0 kg/m² before surgery to 40.9 ± 6.4 kg/m² after surgery ($p<0.001$). With respect to initial nutritional status (30 days before surgery), 107 (87%) subjects were classified as morbidly obese and the remaining ones as grades 1 and 2 obese. After surgical intervention, the number of morbidly obese subjects declined to 48% ($p<0.001$). In addition, 51.1% of the obese subjects were now classified as grades 1 and 2 obese and 0.9% were now classified as overweight. Figure 1 illustrates the percent changes in nutritional status according to gender.

Regarding body fat percentage and fat mass (Figure 2), statistically significant results were observed after the first month of surgery. Mean preoperative fat percentage decreased from 47.8 ± 6.3% before surgery to 45.0 ± 6.9% after surgery ($p<0.001$). Fat mass was reduced by 9.7 ± 4.9 kg 30 days after surgery ($p<0.001$). A fat mass reduction of 0 to 9.9 kg was

observed in 68% of women and in 41.3% of men (p=0.02). In contrast, fat mass reduction ranged from 10.0 to 19.9 kg in 55.1% of men versus 28.7% of women (p=0.02).

Table 3. Body weight loss of the subjects according to gender (n=123).

Body weight loss (kg)	Male		Female		Total	
	n	%	n	%	n	%
Up to 4.9	2	6.9	3	3.2	5	4.0
5.0 to 9.9	1	3.4	19	20.2	20	16.3
10.0 to 14.9	8	27.6	46	49.0	54	43.9
15.0 to 19.9	6	20.7	17	18.1	23	18.7
20.0 to 24.9	7	24.1	5	5.3	12	9.8
> 25.0	5	17.3	4	4.2	9	7.3
Total	29	100.0	94	100.0	123	100.0

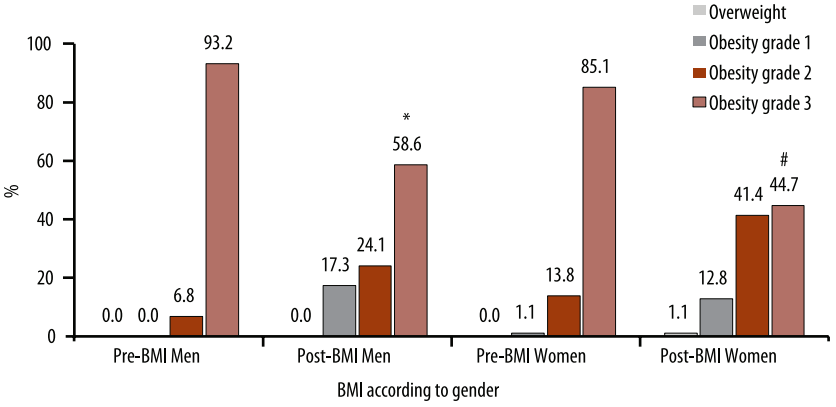

Figure 1. Distribution of pre- and postoperative body mass index (BMI) according to gender.

There was a decrease in mean lean body mass from 65.4 ± 15.3 kg before surgery to 61.0 ± 13.8 kg after surgery, with a difference of 4.4 ± 3.4 kg (p<0.001). Analysis of the category of lean body mass reduction according to gender showed a significant difference for the category of 5 to 13 kg (22.3% and 68.9% in women and men, respectively) (p<0.001). The prevalence of women with a lean body mass reduction of up to 5 kg (69.1%) was higher than that of men (20.6%) (p<0.001).

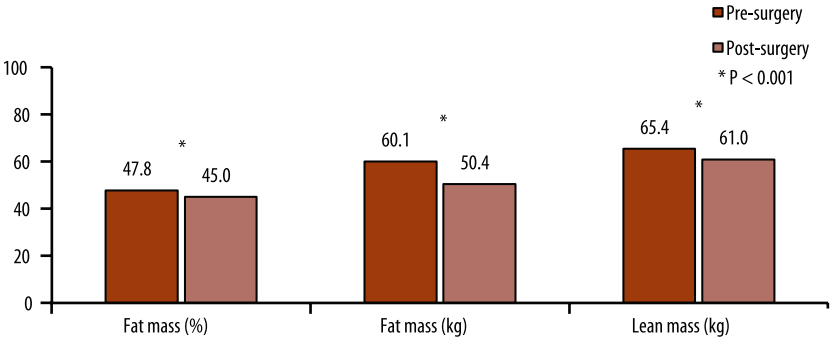

Figure 2. Pre- and postoperative body fat percentage, fat mass and lean body mass.

DISCUSSION

A strength of the present study is the size of the sample which, although obtained by convenience sampling, is much larger than the sample sizes reported in the literature that do not exceed 20 patients[18,19]. In addition, this study provides relevant information since few reports have analyzed the period of 30 days before and 30 days after bariatric surgery. A limitation of this study is the fact that body fat percentage and fat mass were estimated by a double-indirect method (bioelectrical impedance analysis).

There was a predominance of women in the present sample. This finding may reflect the higher frequency of morbid obesity among women[20,21], or even differences in the reasons for seeking treatment[22]. According to the Brazilian Institute of Geography and Statistics (IBGE)[23], 71.3% of patients with grade 3 obesity are women. In a North-American population-based study, Cherala[24] reported a female-to-male ratio of 4:1 among subjects undergoing gastric bypass procedures.

Analysis of weight loss showed that a mean loss in the range of 10.0 to 14.9 kg was the most frequent in both genders, corresponding to a reduction of 11.2%. Few studies evaluating the same postoperative period are available for comparison of the results. Carey et al.[18], studying 19 adult patients (14 women and 5 men) with a mean age of 40.5 years who underwent bariatric surgery at the University of St. Thomas, United States, found a similar body weight reduction of 8.7% (12.3 kg) one month after the procedure. Also in agreement with the present results, Laferrere et al.[19] observed a body weight loss of 9.2 kg 30 days after gastric bypass surgery in a small sample of obese diabetic women (n=8) with a mean age of 44.8 years. In the representative sample of 160 patients studied by Faria et al.[14], most patients were women (76%) and body weight loss was 22.7%, a value higher than that observed in the present study when the same postoperative period was compared.

It is important to note that most studies in the literature investigated longer postoperative periods than the period of 30 days analyzed here. In this respect, Trakhtenbroit et al.[25], studying 10 morbidly obese women undergoing Roux-en-Y gastric bypass at the University of Texas, United States, reported a difference of 18.6% (23.7 kg) in body weight between baseline and the third postoperative month. Comparing body weight measured on the day prior to bariatric surgery and 6 months after surgery in a sample of 15 patients from southeastern Brazil, Santos[15] observed a reduction of 51.4% or 41.4 kg.

In the present study, the mean reduction in BMI was 5.2 kg/m², corresponding to a decrease of 11.2%. Similar results have been reported by Carey et al.[18] and Laferrere et al.[19] who obtained a reduction of 4.2 kg/m² (8.6%) and 3.5 kg/m², respectively, in the first month after surgery. Greater reductions in BMI have been observed in studies analyzing longer postoperative periods. Trakhtenbroit et al.[25] reported a reduction in BMI of 18.6% or 8.9 kg/m² three months after surgery. Santos[15] observed a reduction in BMI of 27.9% (from 55.1 to 39.7 kg/m²) 6 months after surgery. Similarly,

Faria et al.[14], comparing baseline BMI and values obtained 7 months after gastric bypass, found a mean reduction of 25.9% (from 45.8 to 33.9 kg/m²).

The postoperative periods evaluated in other studies need to be taken into account. In this respect, greater losses of body weight and BMI were observed when longer periods after bariatric surgery (more than 3 months) were considered, a fact characteristic of this surgical procedure. The reduction in body weight and, consequently, in BMI is expressive immediately in the first month and tends to accelerate until the sixth month, followed by stabilization between 12 and 18 months after surgery[14].

The mixed technique of Roux-en-Y gastric bypass permits average losses of at least 35% to 40% of initial body weight within 12 to 24 months after surgery[26]. These significant losses render the subjects more susceptible to undesired reductions of lean mass. Although this study did not evaluate the importance of protein supplementation, this approach seems to be fundamental for the maintenance of muscle mass. In the present study, the loss of lean body mass was 4.4 kg. The study by Carey et al.[18] is the only one that evaluated changes in lean mass after the same postoperative period. These authors reported a similar reduction of 3.6 kg. Studies analyzing longer postoperative periods reported reductions in lean mass of 13.7 kg (17.5%) and 6.4 kg (10.4%) after 6 and 3 months, respectively[15,25]. The changes in nutrient absorption caused by surgery manifest in most cases as some type of nutritional deficiency. Low levels of iron, vitamin B12 and calcium have been reported in patients undergoing Roux-en-Y gastric bypass[27], a fact explaining these losses.

Finally, the reduction of body fat mass is the main objective of bariatric surgery. This is achieved by the creation of a gastric pocket with a capacity of 15-50 ml and these changes in the gastrointestinal tract result in an important reduction of calorie intake. As a consequence of lower food intake, Carey et al.[18] observed a reduction of 2.3%, or 8.7 kg, in fat mass in the first month after surgery. Laferrere et al.[19] reported a reduction of 1.8% in fat mass 30 days after surgery. These values are similar to those obtained in the present study. Fat mass reductions of 27.8 kg (40.5%) and 16.1 kg (24.4%) have been reported when the patients were followed up for a longer period of time after surgery (6 and 3 months, respectively)[15, 25].

CONCLUSIONS

Vertical banded Roux-en-Y gastroplasty with or without gastrostomy (Fobi-Capella surgery) significantly reduced body weight, BMI, body fat percentage, and fat mass when the periods of 30 days before and 30 days after surgery were compared. Surgery can therefore be an alternative when conventional treatments of morbid obesity appear to be ineffective, since it improves variables that are directly related to the onset and to the development of comorbidities. Morbid obesity is associated with different comorbidities such as type 2 diabetes, high blood pressure, and inflammatory markers. In this respect, the fat mass loss induced by bariatric surgery may directly attenuate non-communicable diseases.

REFERENCES

1. Vedana EHB, Peres MA, Neves J, Rocha GC, Longo GZ. Prevalência de obesidade e fatores potencialmente causais em adultos em região do sul do Brasil. Arq Bras Endocrinol Metab 2008;52(7):1156-62.
2. World Health Organization. Obesity: preventing and managing the global epidemic: report of a WHO consultation. Geneva: World Health Organization. WHO Technical Report 894. 2000.
3. Brasil. Ministério da saúde. Secretaria de Vigilância em Saúde. Pesquisa de Orçamentos Familiares 2008-2009. Rio de Janeiro: Ministério da Saúde, 2010. Available from: <http://www.ibge.gov.br/home/estatistica/populacao/condicaodevida/pof/2008_2009 _encaa/ pof_20082009_encaa.pdf>. [2013 February 18].
4. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Vigitel Brasil 2011: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília: Ministério da Saúde, 2011. Available from: <http://www.dive.sc.gov.br/conteudos/agravos/Dant/VIGITEL-2011.pdf>. [2013 February 12].
5. Fontaine KR, Redden DT, Wang C, Westfall AO, Allisson DB. Years of life lost due to obesity. JAMA 2003;289(2):187-93.
6. Schmidt MI, Duncan BB, Azevedo e Silva G, Menezes AM, Monteiro CA, Barreto SM, et al. Chronic non-communicable diseases in Brazil: burden and current challenges. Lancet 2011;377(9781):1949-61.
7. Zilbertein B, Galvão Neto M, Ramos AC, Cardoso A. O papel da cirurgia no tratamento da obesidade. Rev Bras Med 2002;59(4):258-64.
8. Wannmacher L. Obesidade: evidências e fantasias. Brasília: Organização Pan-Americana da Saúde/Organização Mundial da Saúde - Brasil, 2003. Available from: <http://portal.saude.gov.br/portal/arquivos/pdf/Obesidade.pdf.> [2013 March 13]
9. Marcelino LF, Patrício ZM. A complexidade da obesidade e o processo de viver após a cirurgia bariátrica: uma questão de saúde coletiva. Cien Saude Colet 2011;16(12):4767-76.
10. Jones JRKB. Experience with the Roux-en-Y gastric by-pass, and commentary on current trends. Obes Surg 2000;10(2):183-5.
11. National Institutes of Health. The practical guide to the identification, evaluation, and treatment of overweight and obesity in adults. The North American Association for the Study of Obesity, National Heart, Lung, and Blood Institute, National Institutes of Health Publication no. 00-4084; 2000. Available from: <http://www.nhlbi.nih.gov/guidelines/obesity/prctgd_c.pdf>. [2013 February 20]
12. Sjostrom L, Narbro K, Sjostrom CD, Karason K, Larsson B, Wedel H, et al. Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med 2007;357(8):741-52.
13. Johnson JM, Maber JW, Samuel I, Heitsbusen D, Doberty C, Dawns RW. Effects of Gastric Bypass procedures on bone mineral density, calcium, parathyroid hormone, and vitamin D. J Gastrointest Surg 2005;9(8):1106-11.
14. Faria OP, Pereira VA, Gangoni CMC, Lins RD, Leite S, Rassi V, et al. Obesos mórbidos tratados com gastroplastia redutora com bypass gástrico em Y de Roux: análise de 160 pacientes. Brasília Med 2002;39(1/4):26-34.
15. Cunha SFC, Sanches M, Faria A, Santos JE, Nonino-Borges CB. Evolução da massa corporal magra após 12 meses da cirurgia bariátrica. Rev Nutr 2010; 23(4):535-41.
16. Lohman T, Roche A, Martorel R. Anthropometric standardization reference manual. Champaign, IL: Human Kinetics Books; 1998.
17. Bioelectrical impedance analysis in body composition measurement: National Institutes of Health Technology Assessment Conference Statement. Am J Clin Nutr 1996; 64(3):524S-532S.
18. Carey DG, Pliego GJ, Raymond RL, Skau KB. Body composition and metabolic changes following bariatric surgery: effects on fat mass, lean mass and basal metabolic rate. Obes Surg 2006;16(12):1602-8.

19. Laferrere B, Heshka S, Wang K, Khan Y, McGinty J, Teixeira J, et al. Incretin levels and effect are markedly enhanced 1 month after Roux-en-Y gastric bypass surgery in obese patients with type 2 diabetes. Diabetes Care 2007;30(7):1709-16.
20. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrbach K, et al. Bariatric surgery: a systematic review and meta-analysis. JAMA 2004;292(14):1724-37.
21. Diniz MFHS, Passos VMZ, Barreto SM, Diniz MTC, Linares DB, Mendes LN. Perfil de pacientes obesos classe III do Sistema Público de Saúde submetidos à gastroplastia em "Y de ROUX", no Hospital das Clínicas da UFMG: altas prevalências de superobesidade, co-morbidades e mortalidade hospitalar. Rev Med Minas Gerais 2008;18(3):183-90.
22. Sjostrom L, Lindroos A, Peltonen M, Torgernson J, Bouchard C, Carlsson B, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. N Engl J Med 2004;351(26):2683-93.
23. Instituto Brasileiro de Geografia e Estatística (2003). Pesquisa de Orçamentos Familiares. 2002-2003. Primeiros resultados. Available from: <www.ibge.gov.br/home/estatistica/populacao/condicaodevida/pof/2002/pof2002.pdf> [2013 March 10].
24. Cherala SS. Gastric bypass surgeries in New Hampshire, 1996-2007. Prev Chronic Dis 2012;9:110089.
25. Trakhtenbroit MA, Leichman JG, Algahim MF. Body weight, insulin resistance, and serum adipokine levels 2 years after 2 types of bariatric surgery. Am J Med 2009;122(5):435-42.
26. Rocha QS, Mendonça SS, Fortes RC. Perda ponderal após gastroplastia em Y de Roux e importância do acompanhamento nutricional: uma revisão de literatura. Com Ciên Saúde 2011;22(1):61-70.
27. Alvarez-Leite JI. Nutrient deficiencies secondary to bariatric surgery. Curr Opin Clin Nutr Metab Care 2004;5(7):569-75.

Corresponding author

Tiago Wally Hartwig
Rua Luís de Camões, 625. Bairro Três Vendas
CEP: 96055-630. Pelotas, RS. Brasil
E-mail: tiagowh@gmail.com