Obesity Surgery (2019) 29:958–963
https://doi.org/10.1007/s11695-018-03628-z

ORIGINAL CONTRIBUTION

Perception of Hunger/Satiety and Nutrient Intake in Women Who Regain Weight in the Postoperative Period After Bariatric Surgery

Flávio Teixeira Vieira[1] · Silvia Leite Campos Martins Faria[1] · Eliane Said Dutra[1] · Marina Kiyomi Ito[1] · Caio Eduardo Gonçalves Reis[1] · Teresa Helena Macedo da Costa[1] · Kênia Mara Baiocchi de Carvalho[1]

Published online: 18 December 2018

Abstract

Objective To investigate the perception of hunger and satiety and its association with nutrient intake in women who regain weight in the postoperative period after bariatric surgery.

Methods Cross-sectional study of adult women divided into three groups: weight regain ($n = 20$), stable weight ($n = 20$) (both at least 24 months after Roux-en-Y gastric bypass surgery), and non-operated obesity ($n = 20$). A visual analogue scale measured hunger/satiety perception while fasting, immediately after finishing a test meal, and 180 min after finishing the test meal. The incremental area above or under the curve was calculated. Food intake was analyzed by 3 days of food recall and adjusted for intraindividual variation. To make between-group comparisons, Mann-Whitney, ANOVA, Kruskal-Wallis, and independent-samples *T* tests and Pearson's correlation were used.

Results There were no between-group differences in incremental areas of hunger/satiety, but protein intake was significantly lower among patients who regained weight compared with those who had stable body weight (0.99 ± 0.23 g/kg body weight vs. 1.17 ± 0.21 g/kg body weight, $p = 0.047$). In the group that regained weight, satiety was correlated positively with usual dietary protein density ($r = 0.541$; $p = 0.017$) and negatively with usual carbohydrate intake ($r = -0.663$; $p = 0.002$).

Conclusion Women who regained weight presented similar perceptions of hunger/satiety to those of patients without weight regain and with non-operated obesity. In patients who regained weight postoperatively, satiety perception was correlated positively with usual dietary protein density and inversely with usual carbohydrate intake.

Keywords Satiety response · Hunger · Dietary assessment · Weight regain · Roux-en-Y gastric bypass

✉ Silvia Leite Campos Martins Faria
silvialeitefaria@gmail.com

Flávio Teixeira Vieira
flavio.nut@hotmail.com

Eliane Said Dutra
elidutra@unb.br

Marina Kiyomi Ito
marinakito@gmail.com

Caio Eduardo Gonçalves Reis
caioedureis@gmail.com

Teresa Helena Macedo da Costa
thmdacosta@gmail.com

Kênia Mara Baiocchi de Carvalho
kenia@unb.br

[1] Graduate Program in Human Nutrition of the University of Brasilia, Brasilia, Brazil

Introduction

Despite the promising metabolic results of the surgical treatment for obesity, especially the Roux-en-Y gastric bypass (RYGB), maintaining the body weight achieved in the postoperative stage has been a challenge, especially at 24 months after surgery. There is a tendency after surgery towards a gradual increase in food consumption [1], which when combined with a sedentary lifestyle favors a positive energy balance and therefore weight regain [2].

Other factors have also been associated with weight regain, such as post-surgical period [3], poor dietary quality [3, 4], and low commitment to clinical appointments [4]. However, whether a low degree of appetite control leads to weight regain is still unclear.

The perception of hunger can be stimulated by the smell of food, mood, advertising, and food media, among others, inducing desire to eat even in the absence of hunger [5]. In

addition, it is not yet known whether the protein's satiety effect, as observed in subjects with and without excess weight [6, 7], is also present in individuals who have undergone bariatric surgery. Our hypothesis is that individuals with weight regain after 24 months of RYGB have lower perception of satiety and it is associated with lower protein density of the diet. Therefore, the objective of this study was to investigate perception of hunger and satiety and its association with nutrient intake in women who regain weight in the postoperative period after RYGB.

Materials and Methods

We conducted a cross-sectional analytical study. The data collection took place between July 2016 and December 2017 with women who underwent RYGB surgery at least 24 months previously: the group with stable weight ($n = 20$) presented excess weight loss (%EWL) greater than 50% of their preoperative weight and weight oscillation lower than 10%. The group with weight regain ($n = 20$) had regained at least 10% of body weight compared with the minimum value reached in the postoperative period. The group with non-operated obesity ($n = 20$) was composed of women with severe obesity (body mass index [BMI] greater than or equal to 40 kg/m^2, or greater than or equal to 35 kg/m^2 with associated comorbidities) who had no recent weight oscillation and were not engaged in weight loss treatment. Participants were recruited through social media, e-mail, and in private and public clinics.

We excluded patients with diabetes and those who became pregnant during the postoperative period, since it influences the evolution of their body weight/hormonal profile.

Body weight in kilograms (kg) (Inbody 720®) and height in meters (Sanny®) were measured. For patients who underwent surgery, total weight loss (%TWL) was calculated. The participants answered a sociodemographic questionnaire that contained questions regarding age and level of education.

We evaluated hunger/satiety perception using a visual analogue scale (VAS) consisting of a 100-mm horizontal line, on which the extremities represented the two maximum response points (positive and negative). This is a validated method specially applied for subjective variables [8, 9]. We asked participants to mark a point on the line that represented their perception in response to each question. The distance between the initial and marked points represented the level of perception for each variable. The question "How hungry do you feel now?" was applied to measure hunger (higher value: greater hunger), while two other questions measured satiety: "Would you like to eat something more?" and "How satisfied do you feel now?" (higher value: lower desire to eat) [8]. The VAS was applied at 3 time points: before (12 h fasting), immediately after, and 180 min after consumption of the test meal. The mixed test meal was composed of 200 mL of coconut water and a chicken salad sandwich, which totaled approximately 270 kcal (62% carbohydrate, 12% protein, and 26% lipid).

We used a 24-h dietary recall and two food records on alternate days, covering 1 day of the weekend to evaluate nutrient intake. The 5-step multiple-pass method was applied for the 24-h dietary recall measurements [10]. The food surveys were transformed from household measures to weights in g using household measurement charts [11]. The data were analyzed using the Nutrition Data System for Research (NDSR) software (Nutrition Coordinating Center, University of Minnesota, Minneapolis, USA) [12], a specialized program for dietary analysis that provides information on ingredients, foods, meals, and daily intake. The method of preparation, type of oil used, added salt, whether visible skins and fats were removed, and whether the food was consumed before or after cooking are some of the criteria considered by the software. Foods and recipes that did not exist in the database were added, considering the food composition of the Brazilian Food Composition Table [13] and food labels. Protein supplements were added to the diet, when applicable. Macronutrients and total energy intake were analyzed, as well as the weight of the ingested foods, with descriptions as absolute values and values adjusted per kg of current weight.

A total of 121 food intake recall/records were adjusted for intraindividual variance to represent the patients' long-term intake (usual intake), as estimated by PC-side software (version 1.02) developed by Iowa State University, USA [14]. The Best Linear Unbiased Predictors (BLUPs) generated by PC-Side corrected for day-to-day variability in macronutrient intake were used for between-group comparisons. The usual protein density of the diet was calculated as [Usual protein (g)/Usual energy (kcal)] × 1000 [15].

Mean and standard deviation (SD) or median and confidence interval (CI) were used for descriptive results. We calculated the incremental area above the curve (iAAC) for hunger perception, and incremental area under the curve (iAUC) for the satiety questions [16]. For comparisons between groups, we applied Mann-Whitney, Kruskal-Wallis, one-way ANOVA, or independent sample *T* tests with Tukey post hoc tests. To analyze the effects of time on the VAS and the group × time interaction, two-way repeated-measure ANOVAs were performed. Pearson's correlation test was applied to investigate the relationship between hunger/satiety perception and nutrient intake.

Results

Only one woman in the non-operated obesity group did not take the VAS hunger/satiety test because of a methodological error during its application. All of the patients were able to consume the test meal. Regarding food intake data, 15 operated patients (6 from the stable weight group) and 3 non-operated patients did not answer the questionnaires. In the

weight regain group, the patients who did not complete the food intake evaluation had a longer postoperative period than those who provided intake data (109.3 ± 37.3 vs. 59.4 ± 13.1 months; $p = 0.001$). There were no differences in terms of the other variables considered (data not presented).

Table 1 presents the patients' sociodemographic and clinical characteristics. Among those who had RYGB, patients who regained weight had a lower educational level and longer post-surgical period. As expected, the weight-regain group presented higher BMI and lower %TWL than the stable weight group did.

There was no significant between-group difference in the patients' hunger/satiety perception at each measured time according to the VAS scale (Fig. 1). There were also no significant differences in incremental areas between the groups' hunger/satiety perception (Table 2).

Surgery time did not present significant correlation with hunger question ($r = 0.282$, $p = 0.078$) nor questions related to the desire to eat ($r = 0.057$, $p = 0.725$) and satiety ($r = 0.139$, $p = 0.394$).

Table 3 presents the energy and macronutrient intake results as absolute values and adjusted for body weight. Patients who regained weight presented lower protein intake (g/kg body weight) than the women who had RYGB and stable weight ($p = 0.047$).

Regarding the correlation between hunger/satiety perception and nutrient intake, in total sample satiety perception was correlated positively with usual dietary protein density ($r = 0.437$; $p = 0.004$). Moreover, among patients who regained weight, satiety was correlated in the same direction with usual dietary protein density ($r = 0.541$; $p = 0.017$), and negatively with usual carbohydrate intake ($r = -0.663$; $p = 0.002$).

Discussion

This study compared hunger/satiety perception in women in the late postoperative period after bariatric surgery who presented weight regain with that in patients whose RYGB surgery was successful and patients with non-operated obesity. The perception of hunger/satiety in response to consumption of a test meal was not significantly different among groups. This finding suggests that long-term weight regain among patients who undergo RYGB surgery is not associated with worsening of appetite perception. Even so, it may be possible to increase the perception of satiety by modulating nutrient intake in patients who regain weight.

As in other studies, patients who regained weight had a longer postoperative period [3, 17], suggesting an adaptive effect of surgery that needs to be explored further. The perceptions of hunger and satiety are complementary, and although they are not the only determinants of food consumption, they influence the behavior of people with obesity [18] and are influenced by the intake of specific nutrients [19]. However, this association has been studied little in patients who undergo bariatric surgery, especially in the late postoperative period.

Although the objective of this study was not to evaluate the influence of eating disorders on the perception of hunger/satiety, the lack of control of these components may be associated with the onset of eating disorders in patients with obesity, whether or not they have undergone bariatric surgery. The presence of eating disorders may be negatively correlated with weight loss [20, 21].

The test meal in the present study had a mixed composition in terms of nutrients and energy supply, which simulated a regular meal. Patients in the late postoperative period had a larger gastric capacity [22], and accordingly, all of the patients tolerated the test meal. Although other studies have evaluated the effects of hormones and hunger after a liquid test meal [23–25], a mixed regular meal seems to be a better way to mimic the patients' normal eating pattern after a long postoperative period [26].

During the first year post-RYGB, there seems to be a reduction in the level of appetite and cravings in the postprandial period compared with that in the preoperative period [27]. This improvement in appetite control may be in response to

Table 1 Sociodemographic characteristics, anthropometry, and postoperative time according to study group (mean ± SD)

	Stable weight $n = 20$	Weight regain $n = 20$	Non-operated obesity $n = 20$
Age (years)[1]	38.1 ± 7.4	42.1 ± 10.7	39.4 ± 9.6
Educational level (years)[2]	15.6 ± 1.3	13.8 ± 2.4[a]	12.5 ± 2.5[a]
BMI (kg/m^2)[1]	27.1 ± 4.0	31.0 ± 4.8[a]	42.2 ± 3.3[a,b]
Preoperative BMI (kg/m^2)[3]	41.7 ± 6.5	41.3 ± 3.5	–
MW[4]	66.8 ± 10.9	67.7 ± 10.4	–
% TWL[4]	34.6 ± 2	24.4 ± 2[a]	–
Postoperative period (months)[3]	52.3 ± 33.0	81.9 ± 36.6[a]	–

[1] One-way ANOVA; [2] Kruskal-Wallis; [3] Mann-Whitney; [4] Independent samples *T* test; *BMI*, body mass index; *MW*, minimal weight after surgery; *TWL*, total weight loss; [a] $p < 0.05$, compared to stable weight group; [b] $p < 0.05$, compared to weight regain group

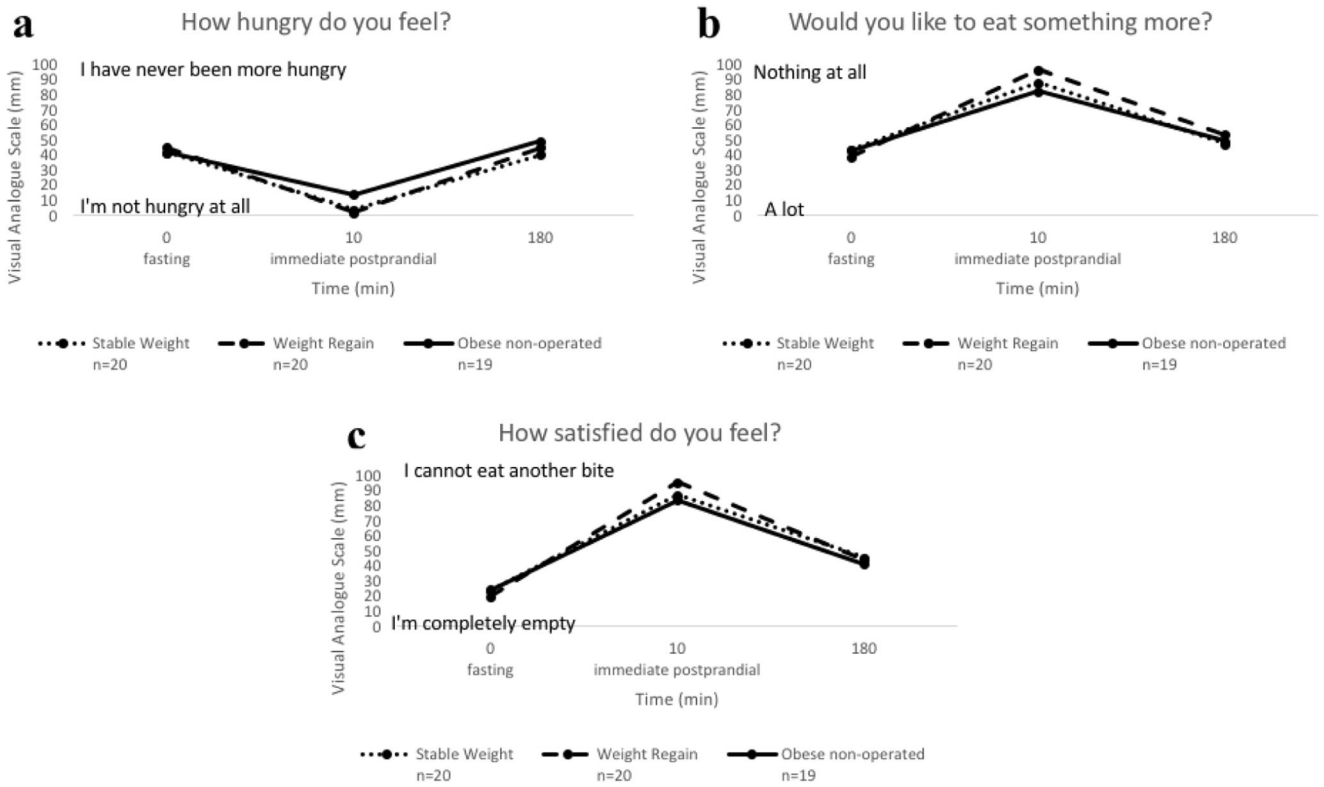

Fig. 1 Visual Analogue Scale for hunger and satiety perception after test meal in women with stable weight, weight regain, and non-operated obesity. Two-way ANOVA with repeated measures, $p > 0.05$

the increased production and secretion of intestinal hormones with anorectic effects, such as Glucagon-like peptide-1 (GLP-1) and Peptide YY (PYY), after RYGB [28]. However, maintenance of the hormonal profile during the late postoperative period, the efficiency of these hormones in controlling appetite, and its association with long-term weight maintenance are unclear. The fact that patients with obesity presented the same level of hunger/satiety perception whether or not they had undergone RYGB suggests that the striking neuroendocrine changes seen during the postoperative period suffered an adaptive effect after time or could not sustain the same pattern of appetite presented in the early postoperative period. Santo et al. (2016) [29] observed that the secretion of intestinal hormones, especially GLP-1, was lower among patients who regained weight than in those with satisfactory weight loss. However, in this study, the efficiency of GLP-1 at facilitating appetite control was not assessed. More studies are necessary to clarify the determining factors of appetite control in this population.

Apart from hunger/satiety perception analysis, food consumption evaluation in patients who undergo bariatric surgery is fundamental. The balance of nutrient intake, especially the adequacy of protein intake, is a key element of dietary counseling for these patients [30]. It is noteworthy that although the patients who regained weight did not present greater energy intake, their carbohydrate and protein intake were higher and lower, respectively, compared with those of the stable weight group. In order to analyze the protein intake, the amount consumed must be corrected by corpulence, since the protein requirement is established in grams per kilogram of body weight [31].

Reid et al. (2016) [32] also observed larger carbohydrate intake among patients who regained weight and that about 40% of the patients did not consume the minimum quantity

Table 2 Incremental area above or under the curve on the hunger or satiety Visual Analogue Scale in women with stable weight, weight regain, and non-operated obesity (median; CI)

	Stable weight $n = 20$	Weight regain $n = 20$	Non-operated obesity $n = 19$
Hungry	363.0 (260.6–712.3)	423.0 (306.5–612.7)	254.0 (157.5–467.7)
Desire to eat	418.8 (287.3–755.8)	688.5 (531.6–883.7)	481.3 (278.2–716.0)
Satiety	832.0 (598.7–1010)	806.5 (707.3–1087)	766.3 (509.5–913.0)

One-way ANOVA or Kruskal-Wallis: no differences found; Hungry: "How hungry do you feel now?"; Desire to eat: "Would you like to eat something more?"; Satiety: "How satisfied do you feel now?"

Table 3 Usual nutrient intake of women with stable weight, weight regain, and non-operated obesity (mean ± SD)

	Stable weight $n = 14$	Weight regain $n = 11$	Non-operated obesity $n = 17$
Grams (g) of food	1333 ± 111	1364 ± 211.1	1528 ± 218.8[a]
Energy (kcal)	1620 ± 223.5	1685 ± 307.6	1878 ± 386.8
Energy/weight (kcal/kg)	23 ± 4.4	21 ± 5.2	18 ± 3.4[a]
Lipid (g)	58.7 ± 12.7	60.0 ± 15.3	65.7 ± 18
Carbohydrate (g)	191.0 ± 23.2	199.4 ± 31.3	225.8 ± 45.5[a]
Protein (g)	83.6 ± 13.5	80.1 ± 13.7	91.2 ± 12.7
Protein/weight (g/kg)	1.2 ± 0.2	1.0 ± 0.2[a]	0.9 ± 0.1[a]
Usual protein density (g/1000 kcal)	49.4 ± 5.3	51.5 ± 4.6	48.0 ± 4.8

One-way ANOVA; [a] $p < 0.05$ compared to stable weight group

of protein recommended. Insufficient protein intake seems to be related to greater loss of muscle mass in the postoperative period [33], which may lead to reduction of resting energy expenditure [34] and hinder body weight maintenance.

It is possible that energy intake was underreported, as is common among patients with obesity [35], because the reported levels of energy intake were incompatible with the excess body weight presented by the patients, especially those who had not undergone RYGB. Even after a postoperative period of 10 years, patients' food ingestion is expected to be 15 to 25% lower than that during the preoperative period [36]. Other studies have also not found differences between the dietary intake of patients who undergo bariatric surgery and regain weight or show insufficient weight loss compared with their respective control groups [37, 38], reinforcing the complexity of food intake assessment, especially in terms of methodological difficulties.

An important result of our study was the positive correlation between the usual dietary protein density and the perception of satiety. Protein density represents the quantity of protein ingested relative to the diet's total energy, and considering that it is the most difficult nutrient to digest, this dietary element may produce greater satiety [39]. However, carbohydrates are metabolized in 15–30 min in the gastrointestinal tract: as they are quickly absorbed, they generate lower satiety [40]. These data are consistent with our findings. In addition to preserving lean mass [41], increasing protein intake can favor satiety and therefore improve the patient's adherence to the prescribed diet.

The limitations of this study are the use of a cross-sectional method, which prevents causality evaluations, and the sample loss related to the unavailability of food consumption data. In addition, behavioral factors such as physical activity, anxiety level, or eating disorders, which may influence the perception of hunger/satiety, were not considered in this analysis. The sampling of only women limits our ability to extrapolate the results. The strong points of this analysis are its well-conducted methodological procedures for both measurement of hunger/satiety perception and evaluation of nutrient intake, which considered intraindividual variance.

Conclusion

Women who regained weight during the late postoperative period after RYGB presented perceptions of hunger/satiety equivalent to those with stable body weight or non-operated obesity. However, in patients who regained weight during the postoperative period, satiety perception was correlated positively with the diet's usual protein density and inversely with usual carbohydrate intake. These findings suggest that patients who regain weight should increase the consumed protein-to-carbohydrate ratio to improve satiety and control energy intake.

Acknowledgments We thank Richard Lipkin, PhD, from Edanz Group (www.edanzediting.com/ac) for editing a draft of this manuscript.

Funding This study was funded by Foundation for Research Support of the Federal District – Brazil (FAPDF), no. 10569.56.30088.09042016.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Statements Regarding Ethics and Consent Informed consent was obtained from all individual participants included in the study. All procedures involving human participants were in accordance with the ethical standards of institutional and/or national research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

1. Giusti V, Theytaz F, Di Vetta V, Clarisse M, Suter M, Tappy L. Energy and macronutrient intake after gastric bypass for morbid obesity: a 3-y observational study focused on protein consumption. Am J Clin Nutr 2016;103(1):18–24.
2. Mundi MS, Lorentz PA, Swain J, et al. Moderate physical activity as predictor of weight loss after bariatric surgery. Obes Surg. 2013;23(10):1645–9.

3. da Silva FBL, Gomes DL, de Carvalho KMB. Poor diet quality and postoperative time are independent risk factors for weight regain after Roux-en-Y gastric bypass. Nutrition. 2016;32(11–12):1250–3.
4. Freire RH, Borges MC, Alvarez-Leite JI, et al. Food quality, physical activity, and nutritional follow-up as determinant of weight regain after Roux-en-Y gastric bypass. Nutrition. 2012;28:53–8.
5. Espel-Huynh HM, Muratore AF, Lowe MR. A narrative review of the construct of hedonic hunger and its measurement by the Power of Food Scale. Obes Sci Pract. 2018;4(3):238–49.
6. Leidy HJ, Armstrong CL, Tang M, et al. The influence of higher protein intake and greater eating frequency on appetite control in overweight and obese men. Obesity (Silver Spring). 2010;18(9):1725–32.
7. Martens EA, Tan SY, Dunlop MV, et al. Protein leverage effects of beef protein on energy intake in humans. Am J Clin Nutr. 2014;99(6):1397–406.
8. Flint A, Raben A, Blundell JE, et al. Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. Int J Obes Relat Metab Disord. 2000;24(1):38–48.
9. Parker BA, Sturm K, Macintosh CG, et al. Relation between food intake and visual analogue scale ratings of appetite and other sensations in healthy older and young subjects. Eur J Clin Nutr. 2004;58(2):212–8.
10. Conway JM, Ingwersen LA, Vinyard BT, et al. Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women. Am J Clin Nutr. 2003;77(5):1171–8.
11. Pinheiro ABV. Tabela para Avaliação de Consumo Alimentar em Medidas Caseiras, 5th edn. Atheneu; 2004.
12. Nutrition Coordinating Center. Nutrition data system for research software. Minneapolis (MN): University of Minnesota; 2016.
13. Núcleo de Estudos e Pesquisas em Alimentação – UNICAMP. Tabela brasileira de composição de alimentos. 5th ed. Campinas: UNICAMP-NEPA; 2011. 161p
14. Center for agricultural and rural development. PC-SIDE software. Iowa State University; 2003.
15. Freedman LS, Guenther PM, Dodd KW, et al. The population distribution of ratios of usual intakes of dietary components that are consumed every day can be estimated from repeated 24-hour recalls. J Nutr. 2010;140(1):111–6.
16. Furchner-Evanson A, Petrisko Y, Howarth L, et al. Type of snack influences satiety responses in adult women. Appetite. 2010;54(3):564–9. Epub 2010 Mar 3
17. Shantavasinkul PC, Omotoshoc P, Corsinod L, et al. Predictors of weight regain in patients who underwent Roux-en-Y gastric bypass surgery. Surg Obes Relat Dis. 2016;12(9):1640–5.
18. Ullrich J, Ernst B, Wilms B, et al. Roux-en Y gastric bypass surgery reduces hedonic hunger and improves dietary habits in severely obese subjects. Obes Surg. 2013;23(1):50–5.
19. Martens EA, Westerterp-Plantenga MS. Protein diets, body weight loss and weight maintenance. Curr Opin Clin Nutr Metab Care. 2014;17(1):75–9.
20. Colles SL, Dixon JB, O'Brien PE. Grazing and loss of control related to eating: two high-risk factors following bariatric surgery. Obesity. 2008;16:615–22.
21. Luiz LB, Brito CLS, Debon LM, et al. Variation of binge eating one year after Roux-en-Y gastric bypass and its relationship with excess weight loss. PLoS One. 2016;11(12):e0167577.
22. Alvarez V, Carrasco F, Cuevas A, et al. Mechanisms of long-term weight regain in patients undergoing sleeve gastrectomy. Nutrition. 2016;32(3):303–8.
23. Yousseif A, Emmanuel J, Karra E, et al. Differential effects of laparoscopic sleeve gastrectomy and laparoscopic gastric bypass on appetite, circulating acyl-ghrelin, peptide YY3-36 and active GLP-1 levels in non-diabetic humans. Obes Surg. 2014;24(2):241–52.
24. Dar MS, Chapman WH, Pender JR, et al. GLP-1 response to a mixed meal: what happens 10 years after Roux-en-Y gastric bypass (RYGB)? Obes Surg. 2012;22:1077–83.
25. Stano S, Alam F, Wu L, et al. Effect of meal size and texture on gastric pouch emptying and glucagon-like peptide 1 after gastric bypass surgery. Surg Obes Relat Dis. 2017;13(12):1975–83.
26. Cardeal MA, Faria SL, Faria OP, et al. Diet-induced thermogenesis in postoperatve Roux-en-Y gastric bypass patients with weight regain. Surg Obes Relat Dis. 2016;12(5):1098–107.
27. Yeh C, Huang HH, Chen SC, et al. Comparison of consumption behavior and appetite sensations among patients with type 2 diabetes mellitus after bariatric surgery. PeerJ. 2017;5:e3090.
28. Dirksen C, Jørgensen NB, Bojsen-Møller KN, et al. Gut hormones, early dumping and resting energy expenditure in patients with good and poor weight loss response after Roux-en-Y gastric bypass. Int J Obes. 2013;37(11):1452–9.
29. Santo MA, Riccioppo D, Pajecki D, et al. Weight regain after gastric bypass: influence of gut hormones. Obes Surg. 2016;26(5):919–25.
30. Fried M, Yumuk V, Oppert JM, et al. Interdisciplinary European guidelines on metabolic and bariatric surgery. Obes Surg. 2014;24(1):42–55.
31. Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. Washington (DC): National Academy Press; 2005.
32. Reid RE, Oparina E, Plourde H, et al. Energy intake and food habits between weight maintainers and Regainers, five years after Roux-en-Y gastric bypass. Can J Diet Pract Res. 2016;77(4):195–8.
33. Ito MK, Gonçalves VSS, Faria SLCM, et al. Effect of protein intake on the protein status and lean mass of post-bariatric surgery patients: a systematic review. Obes Surg. 2017;27(2):502–12.
34. Gomes DL, Oliveira DA, Dutra ES, et al. Resting energy expenditure and body composition of women with weight regain 24 months after bariatric surgery. Obes Surg. 2016;26(7):1443–7.
35. Avelino GF, Previdelli AN, Castro MA, et al. Sub-relato da ingestão energética e fatores associados em estudo de base populacional. Cad Saúde Pública. 2014;30(3):663–8.
36. Kanerva N, Larsson I, Peltonen M, et al. Sociodemographic and lifestyle factors as determinants of energy intake and macronutrient composition: a 10-year follow-up after bariatric surgery. Surg Obes Relat Dis. 2017;13(9):1572–83.
37. Amundsen T, Strømmen M, Martins C. Suboptimal weight loss and weight regain after gastric bypass surgery—postoperative status of energy intake, eating behavior, physical activity, and psychometrics. Obes Surg. 2017;27(5):1316–23.
38. Farias G, Thieme RD, Teixeira LM, et al. Good weight loss responders and poor weight loss responders after Roux-en-Y gastric bypass: clinical and nutritional profiles. Nutr Hosp. 2016;33(5):1108–15.
39. Westerterp-Plantenga MS, Lemmens SG, Westerterp KR. Dietary protein - its role in satiety, energetics, weight loss and health. Br J Nutr. 2012;108(2):S105–12.
40. Russell WR, Baka A, Bjorck I, et al. Impact of diet composition on blood glucose regulation. Crit Rev Food Sci Nutr. 2016;56:541–90.
41. Gomes DL, Moehlecke M, da Silva FBL, et al. Whey protein supplementation enhances body fat and weight loss in women long after bariatric surgery: a randomized controlled trial. Obes Surg. 2017;27(2):424–43.