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Nutritional and behavioral factors related to weight gain after bariatric surgery

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ABSTRACT

Background: *Weight regain (WR) after bariatric surgery is common. Several factors involved in WR have been identified, but there has been little research on specific eating habits such as eating snacks rather than regular meals and being a "sweet-eater".* ***Aim:*** *To determine whether nutritional status, energy and macronutrient intake, eating behaviors and habits were associated with WR in the postoperative period.* ***Material and Methods:*** *We conducted a case-control study of patients who had undergone bariatric surgery. Cases were defined as those patients who gained ≥ 15% of weight in the first two years after surgery and controls as those who gained < 15% of weight. Participants completed a 24-hour dietary recall by phone; weight history was obtained from the medical chart. Logistic regression was used to identify nutritional and behavioral factors significantly related to WR.* ***Results****: Fifty-four cases (77% female, 57% had undergone sleeve gastrectomy) and 50 controls (70% female, 58% had undergone Roux-en-Y gastric bypass surgery) participated. Their mean age was 43 and 40 years, respectively. We observed four eating and lifestyle habits independently associated with greater odds of post-surgery WR, namely being a "sweet-eater", a "grazer", sedentarism and consuming more daily calories.* ***Conclusions****: Eating more daily calories, being a "sweet-eater", a "grazer", and sedentarism were factors related with a greater risk of regaining weight after surgery.*

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Key words: *Bariatric Surgery; Feeding Behavior; Weight Gain.*

Factores nutricionales y conductuales asociados a ganancia de peso después de cirugía bariátrica

Antecedentes*: La ganancia de peso después de la cirugía bariátrica es común. Se han identificado varios factores involucrados en la recuperación de peso, pero existe poca evidencia sobre hábitos alimentarios específicos tales como el patrón picoteador o ser un comedor de dulces.* ***Objetivo:*** *Determinar si el estado nutricional, ingesta calórica y de macronutrientes, patrones de ingesta alimentaria, y conducta alimentaria estuvieron asociados con la recuperación de peso en el período postoperatorio en pacientes de cirugía bariátrica.* ***Material y Métodos****: Estudio de casos y controles de pacientes sometidos a cirugía bariatrica. Los casos fueron definidos como aquellos pacientes que aumentaron ≥ 15% de peso en los*

dos años siguientes a la cirugía, y los controles fueron aquellos que no tuvieron ganancia de peso. Los participantes respondieron telefónicamente un recordatorio de ingesta. El historial de peso se obtuvo de la ficha clínica. Se utilizó una regresión logística para identificar factores nutricionales y de comportamiento relacionados significativamente con la recuperación de peso. ***Resultados****: Participaron 54 casos (77% mujeres; 58% sometidos a manga gástrica) y 50 controles (70 % mujeres; 58% sometidos a baipás gástrico). La edad promedio de ellos fue 43 y 40 años, respectivamente. Se observó cuatro hábitos alimentarios y de estilo de vida asociados independientemente con mayores probabilidades de ganancia de peso postcirugía: comedor de dulces, picoteador, sedentarismo y mayor ingesta calórica diaria.* ***Conclusiones:*** *Una mayor ingesta energética diaria, el consumo de dulces, los picoteos y el sedentarismo se relacionan con una mayor probabilidad de ganancia de peso en el postoperatorio de cirugía bariátrica.*

Palabras claves: *Cirugía Bariátrica; Conducta Alimentaria; Período Postopertorio.*

Obesity represents one of the greatest global public health challenges. It is related to a number of diseases, including type 2 diabetes, cardiovascular diseases, and cancer[1]. Obesity rates vary greatly between countries with rates increasing in low- and middle-income countries, while stagnating in high-income countries[2]. In Chile, the prevalence of obesity among the general population has increased from 22.9% in 2009-2010 to 31.2% in 2016-2017[3].

Bariatric surgery (BS) remains the most effective treatment for durable weight loss and improvement of comorbidities compared with non-surgical alternatives[4]**.** The two most commonly performed bariatric surgeries in the world are Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG). After RYGB and SG the percentage of excess weight lost (EWL) is 62.5% and 53.2% at ≥ 5 years, respectively[5]. Meta-analysis has shown that there is no significant association between EWL and age at surgery, body mass index (BMI) and length of follow-up after the two procedures[5].

Weight regain (WR) occurs frequently after BS[6,7], usually occurring between 12 and 24 months after surgery[5,8,9]. There is no consensus regarding the magnitude of WR that defines surgery success or failure[10]. Some authors define regaining weight to achieve a BMI > 35, on increase in weight of > 10 kg from nadir, any WR, greater than 25% excess weight loss[11].-

It is clear that WR is multifactorial, however, further study is needed on how specific lifestyle, like eating habits relate to risk of WR after BS. The objective of this study was to identify nutritional and behavioral factors associated with WR and quantify nutritional differences in caloric and macronutrient intake among those who regained weight versus those who did not in the postoperative period.

Methods

We conducted a case-control study of patients who had undergone BS (RYGB or SG) at the Centro de Tratamiento de la Obesidad, Hospital Clínico de la Red de Salud UC-Christus in Santiago, Chile. As there is no standard definition of WR after surgery[12,13], cases were defined as those patients with post-surgery weight gain of ≥ 15% two years post-surgery and controls were defined as having a post-surgery weight gain < 15%. In August-October 2012, study personnel contacted a convenience sample of potential participants. First, study personnel identified potential participants via review of the electronic medical record. Next, potential participants were contacted via telephone and invited to participate. The details of the study were explained, informed consent reviewed and an in-person appointment was scheduled to sign the consent form. After signing the consent form, patients were measured and weighed according to standard protocols and follow-up telephone appointments were scheduled to complete nutritional questionnaires. The study

was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Pontificia Universidad Católica de Chile. All participants signed informed consent.

Participants answered questions regarding weight history, eating habits, and completed 24-hour dietary recalls. Dietary recalls represented two weekdays and one weekend day, with values averaged to represent usual dietary intake. With respect to weight history, participants reported their pre-surgery weight, lowest weight post-surgery, and current weight. Information on weight history was verified in the medical record and weight measured in the in-person appointment. Percentage of excess weight loss and percentage of WR[8] were calculated. Percentage of excess weight loss was classified as < 50% and ≥ 50%, as this is identify as a threshold of a successful surgery[14]. Post-surgery eating habits and behaviors were evaluated via a questionnaire that asked about food preferences (sugary/sweet, salty or both), frequency and quantities consumed. We classified a "grazer" as a person who ate snacks or small food portions several times a day without consuming a primary meal. A "sweet-eater" was defined as someone who eats 50% or more of carbohydrates consumed are simple carbohydrates. A "night eater" was defined as someone who 3 or more times per week consumed ≥ 50% of daily calories after 7 PM, who had difficulty sleeping, and who reported not being hungry at breakfast. Alcohol consumption was also determined and categorized in two groups: those dinking alcohol ≥ 2 times per week vs < 2 times per week. Quantity and type of alcohol consumed were also considered. Participants were asked if they consumed a daily multivitamin. Patients were considered active if physical activity (PA) was conducted > 3 times per week for a minimum of 30 minutes. Lastly, average daily consumption of carbohydrates, protein and fat was estimated using data averaged from the three 24-hour dietary recalls using the Food Processor Software.

Statistical analysis

Continuous variables were described with means and standard deviations or median and interquartile range, depending on distribution, and frequencies were reported for categorical variables. Bivariate analyses compared how individual variables differed within cases (those with WR) and controls (those without WR). We used the Student t-test, Mann Whitney U or Fisher exact test, depending on variable type and distribution. Only one question was omitted by a participant. Thus, complete case analysis was utilized. Statistical significance was determined as $p < 0.05$. For multivariable analyses, we conducted an initial logistic regression model that included all covariates that were significantly related to WR in bivariate analyses. A final logistic regression model contained only statistically significant covariates for parsimony. All analyses were conducted using SPSS version 21 (Chicago, USA).

Results

A total of 54 cases and 50 controls agreed to participate in the study. All participants completed the questionnaire. Table 1 describes demographics and pre-surgery anthropometry of the two groups. The number of males/females, age, type of surgery (RYGB vs SG), and time since surgery was similar in both groups. Pre-surgery weight was slightly higher among cases compared to controls: 108.5 vs 102 kg.

Bivariate results are shown in Table 2. We observed that cases were more likely to have been morbidly obese before surgery (BMI > 40 kg/m^2) compared to controls; 51.9 vs 24.0%, $p < 0.004$. No control had percentage of excess weight loss ≥ 50% immediately after surgery, while nearly 80% of those who regained weight post-surgery did ($p < 0.05$). With respect to eating habits, being a "night eater", a "sweet-eater" and a "grazer" was more common among cases, compared to controls ($p < 0.05$). Cases also had a higher daily caloric and carbohydrate intake ($p < 0.05$).

An initial logistic regression model to test factors associated with WR included: having been morbidly obese pre-surgery, "night-eater", "sweet-eater", "grazer", daily vitamin intake, physically active, carbohydrate consumption and daily caloric intake. After adjusting for all other variables in the model, obesity pre-surgery, being a "night-eater", daily vitamin intake, and carbohydrate consumption were no longer related to odds of WR ($p > 0.05$) and were thus removed for parsimony. The final logistic regression model is presented in Table 3. Adjusting for all other variables in the model, we observed four eating

Table 1. Demographic and anthropometric variables between those with post-surgery weight gain ≥ 15% (cases) versus 15% (control)

	Post-surgery weight gain ≥ 15%		p-value
	Yes (n = 54)	No (n = 50)	
Sex			0.36
Female	42 (77.8)	35 (70.0)	
Male	12 (22.2)	15 (30.0)	
Age, years	43.1 ± 10.1	40.8 ± 10.1	0.24
Pre-surgery weight, kilograms	108.5 (78-173)	102 (72-158)	0.05
Surgery Type			0.11
RYGB	23 (42.6)	29 (58.0)	
SG	31 (57.4)	21 (42.0)	
Time since surgery, years	7.5 (4-15)	7 (4-13)	0.14

Variables are means ± standard deviation, median (interquartile range) or n (%). RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy.

Table 2. Bivariate results: independent relationships between covariates and post-surgery weight gain[a]

	Post-surgery weight gain ≥ 15%		p-value[b]
	Yes (n = 54) n (%)	No (n = 50) n (%)	
Pre-operative BMI (kg/m^2)			0.004
<40	26 (48.1)	38 (76.0)	
>40	28 (51.9)	12 (24.0)	
% of excess weight loss after surgery			< 0.001
< 50%	11 (20.4)	50 (100)	
≥ 50%	43 (79.6)	0 (0)	
"Night eater"			0.017
No	37 (68.5)	44 (88.0)	
Yes	17 (31.5)	6 (12.0)	
"Sweet-eater"			< 0.001
No	21 (38.9)	45 (90.0)	
Yes	33 (61.1)	5 (10.0)	
"Grazer"			< 0.001
No	12 (22.2)	46 (92.0)	
Yes	42 (77.8)	4 (8.0)	
Drinks alcohol			0.143
No	28 (51.9)	33 (66.0)	
Yes	26 (48.1)	17 (34.0)	
Takes daily vitamin			< 0.001
No	43 (79.6)	21 (42.0)	
Yes	11 (20.4)	29 (58.0)	
Physically active[c]			<0.001
No	49 (90.7)	12 (26.0)	
Yes	5 (9.3)	37 (74.0)	
Intake alimentary			
Calorie intake, (calories)	1791 ± 488.9	1317 ± 191.0	< 0.001
Carbohydrates, (grams)	190.8 (64.4-365.0)	119.9 (49.0-191.0)	< 0.001
Carbohydrates, (%)	41.56 ± 10.2	36.71 ± 7.5	0.009

[a]Variables expressed as number (%), median (interquartile range) or mean (standard deviation). [b]p-value for Fisher exact, t-test or Mann Whitney U test. [c]Missing = 1 from control group. BMI = body mass index. kg = kilograms. m= meters.

Table 3. Final multivariable logistic regression model of correlates of post-surgery weight gain

	OR	95% CI
"Sweet-eater"	9.7	1.1 - 83.2
"Grazer"	14.4	3.8 - 150.2
Daily calorie intake (per 100 Kcal)	1.3	1.1 - 1.9
Not physically active	25.3	3.9 - 162.0

OR = odds ratio. CI = Confidence interval.

and lifestyle habits independently associated with greater odds of post-surgery WR of ≥ 15%: being a "sweet-eater" (Odds ratio (OR) = 9.7, 95% Confidence Interval (CI) 1.1-83.2), a "grazer" (OR = 14.4, 95% CI 3.8-150.2), not being physically active (OR = 25.3, 95% CI 3.9-162.0) and consuming more daily calories (OR per 100 kcal = 1.3, 95% CI 1.1-1.9).

Discussion

In this study of Chilean patients who underwent BS evaluated, on average, 7 years after surgery, we identified several eating habits that related to greater odds of having regained weight after surgery. Being a "sweet eater", defined as consuming largely simple carbohydrates, and being a "grazer"–a person who eats several small snacks, without a main meal, were both related to significantly higher odds of post-surgery weight gain. Additionally, eating 100 additional daily calories was associated with a 30% increase in odds of WR. Finally, most of the subjects with WR were sedentary.

The present study showed that a higher intake of sweets and the habit of "grazing" were both related to higher odds of WR. However, results related to these habits are mixed. At least two studies conducted up to 2 years after surgery have not reported associations with WR[15,16]. On the other hand, our results are in accordance with the work of Freire and colleagues, who report sweet and snack eating related to WR[17] and, in another study that reported fewer cravings for sweets has been related to better weight loss outcomes[18]. The literature shows that frequent consumption of snacks high in fat and sugar could lead to excessive energy intake from carbohydrates and this behavior may reduce the ability to maintain weight loss[19], however, we were unable to identify articles relating the singular habit of sweet eating and WR after surgery. It is clear that more study is needed on these eating habits, as results are still inconclusive. In the meantime, sweet eating and "grazing" behaviors should not be viewed as potentially predictive of post-surgery WR.

Nearly half (44%) of the overall sample was classified as "grazers", a prevalence similar to that reported by Kofman and colleagues (47%)[20]. These researchers suggest that grazing may be the clinical manifestation of disordered eating following surgery, as binge eating, for example, is difficult in the post-operative period due to a smaller gastric capacity. In our study, grazing, independent of sweet eating, PA, and increased caloric intake related to higher odds of WR. This is an important contribution, as it is often difficult to disentangle overlapping eating habits. In addition, grazing is not only important for WR, but has been related to lower perceived quality of life after surgery[20].

BS impacts caloric intake, most notably in the period immediately following surgery. Over time, however, caloric intake is less restrained, which contributes to postoperative WR. The Swedish Obese Subjects Trial has reported intakes of just under 2000 kcal/day at 4-10 years after surgery[21], values higher than what we observed in our study, which may relate to leisure time PA or under or over reporting in one of the studies. We observed a 30% increase in odds of WR for every 100 additional calories consumed post-surgery. While in our study, participants were interviewed on average 7 years after surgery, eating habits that led to WR (or not) may have been established early after surgery.

A potential benefit of BS is making PA more possible for patients. In addition, PA is an important health habit that protects against WR. After BS, patients are counseled to adhere a healthy lifestyle that includes daily exercise for at least 30 minutes. In our study, although our definition of being physically active was more lenient (30 minutes of PA > 3 times per week), only 9.3% of subjects who regained weight and 40.7% of the overall sample reported being active. The prevalence of PA in the postoperative period appears to vary greatly in studies conducted in other countries, although exact comparisons are difficult as studies use different definitions of PA. Compared to one study conducted in Brazil, using a similar

definition for PA, our sample had lower rates, especially among who regained weight. Among patients who had undergone surgery between 1 and 7 years prior to study participation, Horta Freire and colleagues reported that 45% of patients who regained weight and 55% of patients overall were physically active[17]. In multivariable analyses, we found that not being physically active was related to higher odds of WR, which is consistent with other reports[17], although the magnitude of effect was much higher in our study (OR = 25.3). This may relate to the overall low rate of PA among Chilean adults, compared to other countries. In the most recent national health survey (2016 - 2017)[3], only 13.8% of Chileans between 30 and 49 years of age are physically active[3]. In Brazil, by contrast, 29.8% of adults surveyed in a nationally representative study report being PA at least 3 times per week[22]. While intervention studies to increase PA among patients undergoing bariatric surgery following the intervention have shown improvements[23], studies are needed to test whether the same interventions are successful in a context where overall rates of PA among adults are so low.

Our results should be interpreted considering several limitations. First, the sample size was a limitation, which led to very large confidence intervals of our estimates. A greater sample size would have allowed for greater precision of estimates. Second, we did not evaluate eating habits and PA before surgery. Changing habits between the pre and postoperative period might be particularly important with respect to WR[24]. In addition, our sample size and design (case-control) may limit our ability to generalize to a larger population of bariatric patients, however, our findings can be used for hypothesis generation or as preliminary information for a subsequent, larger prospective study. Understanding habits preoperatively could assist interdisciplinary treatment teams to tailor post-operative counseling and intervention (if available). Finally, much of the information was obtained via telephone appointments. Although information was confirmed, when possible (weight measurements pre- and post-surgery and current weight) with objective measurements available in the medical chart, data maybe be subject to information bias. Our study focused on behavioral and nutritional factors that may relate to WR and did not include other causes of WR such as associated metabolic or psychological pathologies or gastric remnant dilation. Future studies may consider including these factors in order to determine the relative importance of each, and on the other hand more studies are needed to validate our findings and should, ideally, prospectively collect information on eating habits and WR. Determining which eating habits relate to WR at which time point, is important for tailoring pre- and post-surgery counseling.

Conclusions

Factors independently associated with greater odds of WR among our sample of Chilean adults were the dietary habits of "grazing" and being a "sweets eater", eating additional calories, and not being physically active. Identifying these factors in the pre-operative period may help to better tailor preparation for surgery and post-operative follow-up in order to prevent excessive post-surgical WR. The factors associated with better prognosis remain controversial and may be particular to each population or multidisciplinary therapeutic approach. Understanding the reasons behind unfavorable outcomes may contribute to create specific guidelines for these patients.

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