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ORIGINAL CONTRIBUTIONS

The Effect of Roux-en-Y Gastric Bypass and Sleeve Gastrectomy Surgery on Dietary Intake, Food Preferences, and Gastrointestinal Symptoms in Post-Surgical Morbidly Obese Lebanese Subjects: A Cross-Sectional Pilot Study

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Abstract
Background Data on gastrointestinal (GI) and dietary changes following bariatric surgery are scarce in the Middle Eastern region. The objective of this work was to retrospectively compare dietary intake, food preferences, and GI symptoms in subjects with extreme obesity after Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG).
Methods Sixty subjects equally divided between RYGB and SG with a postoperative period of ≥6 months were recruited for a retrospective, non-randomized, and observational study. All subjects completed three questionnaires (GI symptoms, food preferences, and quantitative food frequency questionnaire (FFQ)) and three 24-h recalls.
Results At one year postoperatively, both surgical groups showed similar percentage of excess weight loss that exceeded 50 %. In addition, percentage of carbohydrate, protein, and sugar intake from total energy, frequency of daily consumption from the eight food categories and daily energy intake were comparable between surgical groups. RYGB subjects consumed significantly more fruits and juices from total energy ($P<0.05$) whereas SG subjects tended to consume more sweets and desserts. Heartburn ($P<0.001$), regurgitation ($P<0.01$), nausea ($P<0.01$), vomiting ($P<0.001$), and constipation ($P<0.05$) were significantly more frequent among SG subjects. Flatulence ($P<0.001$) and diarrhea ($P<0.05$), as well as dizziness ($P<0.001$), and fast heartbeat ($P<0.05$) after eating were significantly more frequent after RYGB.
Conclusions There were no major differences in dietary intake and food preferences between RYGB and SG groups. There was a trend for sweet-eating in SG subjects with less dumping symptoms to suggest different mechanisms of action for each procedure, which might impact eating behavior.

Keywords Gastric bypass · Sleeve gastrectomy · Food preferences · Surgery complications · Dietary intake

Introduction

Adult obesity (BMI≥30 kg/m^2) rates in the Middle East have reached alarming levels, as high as 43.8 % in the Kingdom of Saudi Arabia [1]. In Lebanon, obesity rates have significantly increased from 17.4 to 28.2 % among adults (1997 to 2009) [2]. Several environmental factors have been attributed to the above high obesity rates [3, 4].

Bariatric surgery appears to be the only effective and enduring treatment for morbid obesity when dieting and exercise do not produce the expected weight loss [5–8]. Roux-en-Y gastric bypass (RYGB) is the most frequently performed bariatric surgery in the USA [9]. Sleeve gastrectomy (SG) surgery has also gained popularity in the last few years due to its technical simplicity and minimal invasiveness compared to RYGB [10–13]. Both procedures have yielded significant (>50 %) excess weight loss (EWL) [14–24].

Several gastrointestinal (GI) symptoms have been documented following bariatric surgery, particularly vomiting and nausea following the two above procedures [22, 25–29],

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dumping syndrome [29–31] and changes in fecal consistency [32] post-RYGB, and gastro-esophageal acid reflux disease (GERD) after SG [13]. In addition, changes in food preference have been documented after different types of bariatric surgery [33, 34]. Restrictive operations such as the vertical banded gastroplasty (VBG) lead to the consumption of high-calorie soft sweet foods, especially in liquid form, that can pass through small openings in the GI tract [35, 36]. Moreover, distinctive differences in food preference between VBG and RYGB patients were noted [37]. The SG procedure is relatively new, and its mechanisms of action are still not elucidated. Most bariatric surgeons place the SG as a restrictive operation; however, SG entails resection of more than 60 % of the stomach. As such, the SG may exhibit different eating behavior than restrictive procedures such as VBG.

To date, there is only a single study in Spain [38] that has assessed dietary intake and food preferences between prospective RYGB and SG subjects, and no similar study has been conducted in the Middle East. A good understanding of the changes in food preferences will be useful for maintaining long-term weight loss post-surgery and for developing nutrition care strategies, especially given the scarcity of data on SG. The objective of this pilot study was to compare the effect of RYGB and SG surgeries on dietary intake (energy and macronutrients), food preferences, and gastrointestinal symptoms in post-surgical extremely obese subjects.

Materials and Methods

Study Setting and Design

Subject recruitment and data collection took place at the American University of Beirut Medical Center (AUBMC; private hospital) in Beirut, Lebanon throughout a 16-month period (March 2011–June 2012; cross-sectional study).

Subject Selection and Recruitment

Sixty post-surgical subjects, 30 patients with RYGB procedure and 30 patients with SG procedure, participated in this study. Indications for surgery followed the National Institute of Health criteria [39]. Both types of operations were performed, laproscopically and in a similar manner within each type of surgery [40–43], by Bassem Safadi, M.D. at AUBMC or its affiliated facilities.

Subjects were recruited in a retrospective fashion from the bariatric surgery database available at the AUBMC. They fulfilled the following criteria: 1) postoperative period of ≥6 months, absence of 2) pregnancy, 3) substance abuse (alcohol or drugs), 4) severe medical/physiological illness, 5) history of major operations on the GI tract, and 6) major postoperative complications after bariatric surgery.

Subjects were first contacted via telephone by a research team member to obtain oral consent for participating in this study and for accessing their medical records. The Institutional Review Board at AUB approved the study protocol. Informed consent was obtained from all individual participants included in the study

Data Collection

Demographic Data and Subjects Characteristics

Information about gender, age, height, preoperative weight, postoperative weight at one year, preoperative comorbidities, and date of bariatric surgery were extracted from the patients' medical records. Subjects completed, during an initial interview with a licensed dietitian, three questionnaires: a food acceptability/preference questionnaire, a food frequency questionnaire (FFQ), and a GI symptom questionnaire.

Dietary Assessment

Quantitative FFQ measured the frequency of consumption for 141 foods and beverages, as aggregated into 11 categories: bread and cereals, dairy products, fruits, vegetables, legumes, protein foods, fats and oils, sweets and desserts, beverages, alcohol, and fast food. The questionnaire was a slightly modified version of a previously developed and validated one [44, 45]. Subjects were asked about their eating pattern in the month preceding the initial interview and to indicate their usual intake from each of the food items per day, week, or month, while determining their usual serving size consumed relative to an indicated standard serving. "Rarely/Never" was also an option.

Participants completed three 24-h dietary recalls (covering two weekdays and one weekend day) through a personal interview with the dietitian, whereby they were asked to recall and report all foods and beverages consumed in the previous 24 h [46] following common standardized procedures [47].

Food Acceptability

Subjects rated the acceptability of foods or beverages on a 9-point hedonic scale [48]. "Never tried" was also an option. The acceptability questionnaire included 43 selected foods, which were culture-specific to the Middle Eastern traditional diet, from the following food groups: starch-based foods, fruits, vegetables, dairy products, sweets and sweetened beverages, fats and oils, nuts, meats, legumes, as well as eggs, and mixed dishes.

Gastrointestinal Symptoms (GI) Questionnaire

Subjects reported any of the 17 listed gastrointestinal symptoms that they had experienced during the last month before the day of the interview and rated their intensities on a 7-point scale ranging from "none" (1) to "unbearable" (7) [49].

Data and Statistical Analysis

Main variables from the questionnaires and 24-h recalls included three continuous variables: age (years), weight (kg), and postoperative period (months) and three discrete variables: gender (male-female), surgery type (RYGB-SG), and preoperative comorbidities classified into three groups (none, one comorbidity, and two or more comorbidities). Anthropometric measurements included weight and BMI one year after surgery and were presented as the mean difference (Δ), in addition to %EWL which was computed for each subject as described by Kruseman et al. [50]. Data for the 1-year postoperative weight/weight loss was obtained from the medical records of the subjects (before or after the interview). Percentage frequency of occurrence of each GI symptom was calculated for each surgery type and tested for significance using Fisher's exact test. The acceptability model included panelist as a random variable and surgical procedure as a fixed effect and two-way interactions. Frequency of daily consumption (FDC) of each food item in the FFQ, as described by Issa et al. [45] was computed as servings/day, after which FDC from each food category was calculated for gender and surgery type. The Nutritionist Pro Diet Analysis software (Axxya Systems, 2009, Stafford, TX) was used for the analysis of the 24-h dietary recalls. All statistical analyses were performed in SAS® statistical software (version 9.02, SAS Institute Inc., Cary, NC). Significant means were separated by Tukey's difference test.

Results

Demographic and Anthropometric Measurements

Subjects' demographic and anthropometric measurements are shown in Table 1. Participants' age ranged between 17 and 66 years. The SG group had more females and was younger than the RYGB group but the groups did not differ on the other variables.

Weight Loss

One year postoperatively, RYGB and SG resulted in similar weight loss as illustrated by comparable mean reductions in weight and BMI, and proportion with more than 50 % EWL, in both groups (Fig. 1).

Table 1 Demographic and anthrompometric measurements of subjects[a]

Variable		RYGB[b] (n=30)	SG[c] (n=30)	P value
Gender[d]	Males	16 (53)	8 (27)	0.035[e]
	Females	14 (47)	22 (73)	
Age (years)		39.6±11.3	33.0±12.3	0.034
Comorbidities[df]	0	12 (40)	19 (63)	0.142[e]
	1	7 (23)	6 (20)	
	≥2	11 (37)	5 (17)	
Postoperative period (months)		22.4±17.1	23.4±11.5	0.789
Preoperative weight (kg)		124.0±21.5	115.4±20.7	0.121
Postoperative weight[g] (kg)		85.2±16.1	79.3±14.3	0.138
Preoperative BMI (kg/m^2)		42.7±5.2	41.2±4.1	0.218
Postoperative BMI[h] (kg/m^2)		29.4±4.7	28.3±3.3	0.302

[a] Data presented as mean±SD

[b] *RYGB* Roux-en-Y gastric bypass

[c] *SG* sleeve gastrectomy

[d] Data presented as *n* (%)

[e] *P* value calculated using the X^2 test

[f] Values represent preoperative comorbidities: 0=none or absence of comorbidities, 1=presence of one comorbidity, and ≥2=presence of two or more comorbidities

[g] Mean values of weight one year following surgery

[h] Mean values of BMI one year following surgery

Dietary Intake

Mean total energy intake was higher in RYGB (1555±657 Kcal) participants than in SG (1373±606 Kcal) subjects, although there was no significant difference. No differences existed between the RYGB and SG groups on any of the macronutrients (Fig. 2).

Surgery type had no significant effect on any of the eight FDC food categories of the FFQ (Fig. 3). Despite the absence of significant differences, there was a trend for subjects with

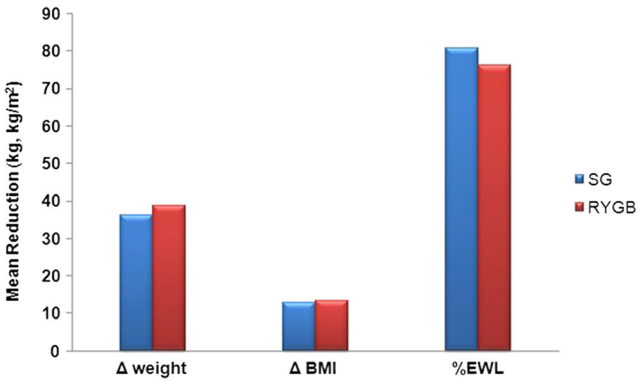

Fig. 1 Means of individual reductions (Δ) in weight and BMI, and percentage excess weight loss (%EWL), from prior to one year after SG and RYGB surgery. *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass

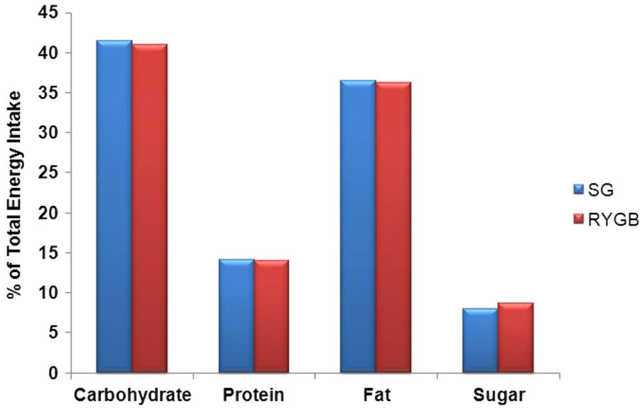

Fig. 2 Mean percentage of the carbohydrate, protein, fat, and sugar intake from total energy for SG and RYGB. *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass. *$P<0.05$

RYGB for higher daily consumption of bread and cereals, vegetables, protein foods, while SG subjects tended to consume more sweets and desserts.

Figure 4 illustrates the percentage from total energy intake contributed by each food category for the two types of operation. There was a significantly higher consumption only for fruits and juices by RYGB subjects ($P<0.05$; Fig. 4). However, given the huge difference in magnitude in percentage of total energy intake from sweets and desserts between the RYGB and SG groups (Fig. 4), the above result may have practical implications. Subjects with SG showed a trend of a higher mean percentage intake of dairy products and vegetables from total energy and lower mean percentage intake of bread and cereals, protein foods, fats and oils, and beverages as compared to the RYGB group.

Food Acceptability

Subjects with SG had significantly higher acceptability ratings for apple and mixed nuts compared to RYGB subjects ($P<0.05$). There was no significant difference in the acceptability rating of other food items between the two groups. Mean acceptability ratings ranged between 3.1 for shakes by RYGB subjects and 7.5 for chocolate bars by SG participants. Foods high in fat and sugar such as croissant, chocolate bars, juices, and potato chips were assigned acceptability ratings with more than one point difference, with higher ratings for SG subjects, although not significantly.

GI Symptoms

Frequency of occurrence of GI symptoms in RYGB and SG subjects within four weeks prior to the interview is summarized in Table 2. Abdominal and stomach pain were rarely reported. Abdominal rumbling, bloating, loss of appetite, belching, as well as fullness, tiredness, and cold sweats after eating were common symptoms and similar in both groups. Heartburn, vomiting ($P<0.001$), regurgitation, nausea ($P<0.01$), and constipation ($P<0.05$) were significantly more frequent among SG. Flatulence, dizziness ($P<0.001$), diarrhea, and fast heartbeat after eating ($P<0.05$) were significantly more prevalent after RYGB.

Discussion

Mean %EWL at one year following SG surgery (80.6 %) exceeded (58–70 % EWL) [17, 18, 22], or was similar to other studies (83 % EWL) [51]. Heartburn and regurgitation were more common after SG surgery, whereas dumping syndrome was more prevalent after RYGB, in line with previous published data [13, 19, 30, 52]. SG is a restrictive operation, and therefore, vomiting and acid reflux is expected, especially when patients eat quickly [22]. Dumping syndrome is well described after gastric bypass and is thought to be due to rapid influx of sugar into the small intestine, leading to a rapid and high surge in insulin, which causes hypoglycemia [29]. This highlights that these two procedures are physiologically different [19, 38, 53].

Both groups consumed comparable caloric intake and comparable macronutrient intake from total energy, a finding similar to that noted by Moize et al. [38]. The percentage fat intake from total energy was high and exceeded the recommended level of 30 % in both groups, as previously reported to be in the range of 33–39 % after RYGB or VBG [37, 50, 54, 55].

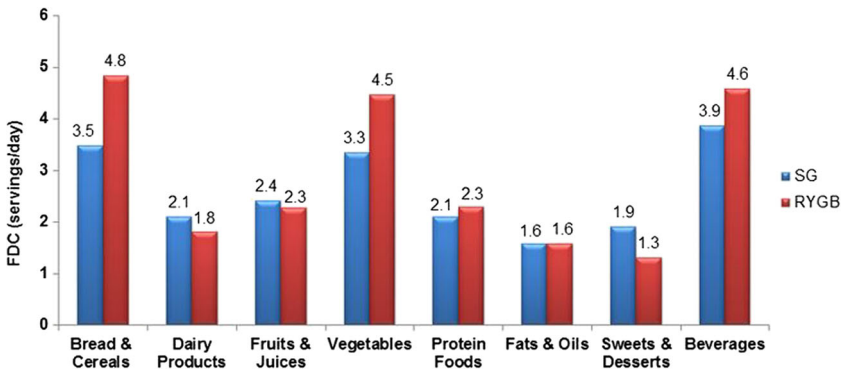

Fig. 3 Means of the frequency of daily consumption (FDC) of each food category for SG and RYGB. *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass

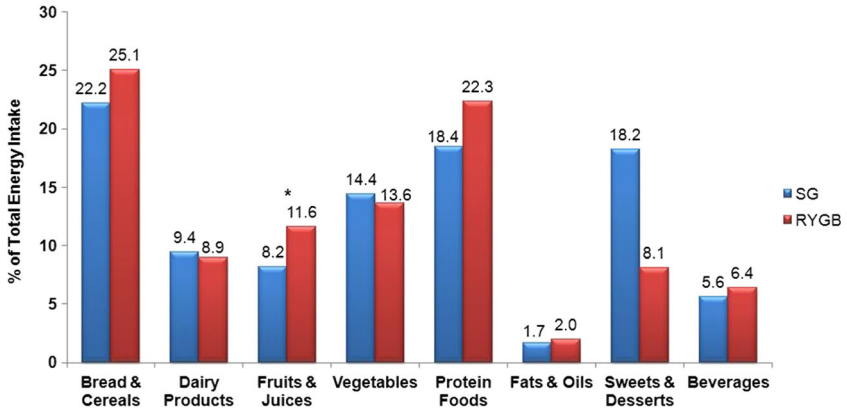

Fig. 4 Mean percentage of the food category intake from total energy for SG and RYGB. *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass. *$P<0.05$

Surgery type did not have a significant effect on any of the food categories FDCs; however, there was a trend of SG subjects consuming dairy products and sweets and desserts more frequently than RYGB subjects. On the other hand, the trend for higher consumption among RYGB subjects for bread and cereals, vegetables, and beverages may have resulted in the significantly higher caloric intake in the RYGB group. It was reported that average food selection rate among RYGB subjects was the lowest for the sweets group [56] and that most SG subjects consumed dairy products during the first year postoperatively [57], after which they increased their consumption of soft-calorie, high-sugar, and fatty foods [57]. This latter trend was related to a significant reduction of the hedonic drive to consume palatable foods [58]. Postoperative period had no significant effect on the FDC of any food category unlike previous work [55].

Table 2 Frequency of occurrence of gastrointestinal (GI) symptoms in subjects throughout four weeks postoperatively[a]

Gastrointestinal (GI) symptoms	RYGB[b] (n=30)	SG[c] (n=30)
Abdominal pain	4 (13)	3 (11)
Stomach pain	3 (11)	2 (8)
Abdominal rumbling	19 (63)	17 (57)
Bloating	17 (57)	15 (50)
Loss of appetite	14 (47)	15 (50)
Belching	15 (50)	14 (47)
Fullness after eating	27 (90)	27 (90)
Heartburn	1 (3)	16 (53)***
Regurgitation	6 (20)	12 (40)**
Nausea	7 (23)	13 (43)**
Vomiting	5 (17)	17 (57)***
Empty feeling	12 (40)	16 (53)
Constipation	13 (43)	18 (60)*
Flatulence	26 (87)***	15 (50)
Diarrhea	8 (27)*	4 (13)
Dumping syndrome		
Tiredness after eating	18 (60)	18 (60)
Cold sweats after eating	12 (40)	10 (33)
Dizziness after eating	11 (37)***	4 (13)
Fast heart beat after eating	12 (40)*	7 (23)

[a] Data presented as n (%)

[b] *RYGB* Roux-en-Y gastric bypass

[c] *SG* sleeve gastectomy

*$P<0.05$; **$P<0.01$; ***$P<0.001$ in the Fisher's exact test

Our results showed significantly higher consumption of fruits and juices from total energy by RYGB compared to SG subjects, and a large magnitude difference for sweets and desserts with a higher value for the SG group. Significantly lower intake of high-calorie liquids and significantly higher intake of fruits among RYGB subjects compared to VBG subjects were obtained at one year postoperatively [35, 37]. Olbers et al. related the above food selection trends to the "sweet-eating" trends among VBG subjects, which is consistent with our SG subjects' trend [37]. Other studies demonstrated increased consumption of high-calorie beverages by RYGB subjects after surgery, despite reported intolerance to sweets and/or dumping syndrome [59–62]. The revealed incidents of dumping syndrome in our RYGB subjects suggest that the dumping phenomenon did not deter subjects from consuming energy-dense food items that are rich in sugar. Our SG subjects had higher intake of sweets and desserts, as well as calories and fat from the latter category, compared to RYGB subjects. This is in agreement with studies that have had significantly higher intake of non-liquid sweets by VBG subjects compared to RYGB subjects [35, 37] and a higher consumption of soft-calorie and high-sugar and fatty foods among SG subjects after one year of postoperative follow-up [57].

The SG group showed higher mean percentage intake of dairy products from total energy and lower mean percentage intake of bread and cereals and protein foods versus the RYGB group, although not significantly (Fig. 4) [63, 64]. In general, dry, sticky, gummy, or stringy foods (such as red meat, bread, and raw vegetables) represent the biggest problems and are poorly tolerated following bariatric surgery [65].

This especially occurs during the first few months and up to two years post-surgery (which comprises the mean postoperative period in our study), whereby a high degree of intolerance to various quantities and varieties of food occurs [56], after which food aversion and intolerance subside, probably due to a physiological and cognitive adaptation [56, 63, 66]. Nevertheless, subjects from both surgery groups eventually exhibited food tolerance and good quality of eating as evident by consumption of all food groups and categories, in a similar manner to results obtained two to four years post-surgery [64].

The findings of the current pilot study do confirm, to some extent, the absence of any major differences in food preferences and food intake, as ascertained by the only previous study that compared RYGB and SG subjects. This work is the first pilot study to examine the differences in dietary intake and food preferences between RYGB and SG subjects in the Middle East. The use of an acceptability scale has not been common in previous studies, and none of the previous studies have computed percentage sugar intake from total energy but rather evaluated sugar intake from the diet by computing mean percentage of calories derived from specific food groups high in sugar content, such as sweets and desserts, etc. A larger number of subjects and specific postoperative periods, or repeated measures over time, would have allowed more comprehensive conclusions. Future research should preferably rely on comparing preoperative and postoperative measurements. Coupling this type of work with biochemical measurements of the different appetite hormones has the potential of defining the cycle integrating food preferences, the new GI anatomy, surgical complications, and appetite regulation, hence aiming at providing a clearer insight on successful weight loss strategies.

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Conflict of Interest Sibelle El Labban, Bassem Safadi, and Ammar Olabi declare that they have no conflict of interest.

Ethical Approval All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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

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