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Changes in Dietary Intake and Eating Behavior in Adolescents After Bariatric Surgery: An Ancillary Study to the Teen-LABS Consortium

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Conflict of Interest:

Author A reports received consulting fees from the following: BARONova, Ethicon Endosurgery, Medtronic and Novo Nordisk. Author B reports receiving fees for serving on the Advisory Board for Orexigen Pharmaceutical and Nutrisystem. He reports receiving grants and advisory board fees from Novo Nordisk and Weight Watchers. He also reports receiving grant funding from Eisai Pharmaceutical and royalties from Guilford Press for two edited books. Author C reports consulting fees from Sanofi Corporation and grant funding from Ethicon Endosurgery.

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Abstract

Background—A growing number of studies suggest that bariatric surgery is safe and effective for adolescents with severe obesity. However, surprisingly little is known about changes in dietary intake and eating behavior of adolescents who undergo bariatric surgery.

Objective—Investigate changes in dietary intake and eating behavior of adolescents with obesity who underwent bariatric surgery (n = 119) or lifestyle modification (LM) (n = 169).

Setting—University-based health systems.

Methods—A prospective investigation of 288 participants (219 female and 69 male) prior to bariatric surgery or LM and again 6, 12, and 24 months (surgery patients only) after treatment. Measures included changes in weight, macronutrient intake, eating behavior, and relevant demographic and physiological variables.

Results—Adolescents who underwent bariatric surgery experienced significantly greater weight loss than those who received LM. The two groups differed in self-reported intake of a number of macronutrients at 6 and 12 months from baseline, but not total caloric intake. Patients treated with surgery, compared to those treated with LM, also reported significantly greater reductions in a number of disordered eating symptoms. After bariatric surgery, greater weight loss from postoperative month 6 to 12 was associated with self-reported weight consciousness, craving for sweets, and consumption of zinc.

Conclusions—Adolescents who underwent bariatric surgery, compared to those who received LM, reported significantly greater reductions in weight after one year. They also reported greater reductions in disordered eating symptoms. These findings provide new information on changes in dietary intake and eating behavior among adolescents who undergo bariatric surgery.

Keywords

bariatric surgery; adolescence; caloric intake; dietary restraint; hunger disinhibition

Introduction

The prevalence of childhood and adolescent obesity has tripled in the past three decades.[1] This increase has been accompanied by a dramatic rise in obesity-related health complications.[2–3] A relatively modest body of research has focused on the treatment of adolescent obesity.[4] Trials investigating the efficacy of behavioral and pharmacological treatments suggest that adolescents typically lose 5% of their initial weight.[5–6] The

increase in the number of adolescents with severe obesity, coupled with the modest results from more conservative treatment approaches, bariatric surgery has become an increasingly accepted treatment for adolescents with severe obesity.[7]

A growing number of studies have demonstrated the safety and efficacy of bariatric surgery for adolescents.[8–10] Adolescents typically lose 25–35% of their body weight within the first one to two years from surgery and experience significant improvements in weight-related health problems.[8–10] Despite these overall positive outcomes, there is a growing appreciation in the adult literature that psychosocial and behavioral variables are associated with postoperative outcomes.[11–15] For example, studies have suggested that adults presenting for bariatric surgery report consuming 2,400 kilocalories per day (kcal/d) on average, which has likely contributed to the development and maintenance of severe obesity.[16–18] Prior to surgery, adults report increased levels of disinhibition (tendency to lose control over food intake) and hunger.[16–17,19] A substantial minority of patients meet diagnostic criteria for Binge Eating Disorder (BED) or report subclinical features of the condition.[20–21] Disordered eating behavior prior to surgery has been associated with smaller postoperative weight losses.[22–24]

There has been little study of these issues in adolescents who undergo bariatric surgery.[25–30] Dietary intake and eating behaviors may be of even greater importance for adolescents, as they will have to engage in the behavioral requirements of bariatric surgery for the entirety of their lives. The present study was designed to assess changes in dietary intake and eating behavior in adolescents who underwent bariatric surgery in comparison to adolescents with obesity who participated in a lifestyle modification (LM) program. We hypothesized that adolescents undergoing bariatric surgery would report greater reductions in daily caloric intake and disordered eating symptoms and reduced consumption of fat and sugar compared to adolescents treated with LM.

Materials and Methods

Participants

This analysis utilized data collected from an ancillary study to the Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) Study, a prospective multi-institutional observational study, designed to assess the safety and efficacy of bariatric surgery for adolescents.[8–9] The consortium provided a unique opportunity to investigate dietary intake and eating behaviors in a large and diverse sample. One-hundred and nineteen individuals participating in the Teen-LABS study were recruited. For a comparison group, 169 adolescents who presented for LM for weight reduction through a study at the Children's Hospital of Philadelphia and Geisinger Health System were used.[31] Study participants were not randomly assigned to bariatric surgery or lifestyle modification. The IRBs at all participating institutions approved the study. All participants provided informed consent. Participants were compensated for their time. The study was registered with www.clinicaltrials.gov (NCT identifier: NCT00721838).

Participants who underwent surgery met the inclusion criteria of the Teen-LABS study and the accepted medical and mental health criteria for bariatric surgery.[32] All of the surgery

sites required preoperative medical weight management prior to surgery.[33] The extent of medical weight management varied between sites, but in all cases, surgery candidates had regularly scheduled sessions with a dietitian or other member of the bariatric surgery team for 6 to 12 months to be educated on the dietary requirements of surgery. Several, but not all, of Teen-LABS sites and surgeons required patients to consume a liquid diet for the two weeks prior to surgery with the objective of reducing the size of the left lobe of the liver. LM participants were asked to consume a nutritionally balanced deficit diet of 1300–1500 kcal/d and advised to follow a standard behavioral modification program aimed at improving eating behavior and increasing physical activity.[31]

Measures

Approximately 1–4 weeks prior to bariatric surgery or the onset of LM, participants completed the assessments listed below. Participants who underwent surgery completed these assessments at baseline and 6, 12, and 24 months postoperatively; those who received LM completed the assessments at baseline and 6 and 12 months from the onset of treatment, as that investigation ended after one year.

Dietary Intake

Dietary intake was assessed by the Minnesota Nutrition Data System (NDR).[34] Trained nutritionists from Pennsylvania State University, Department of Nutritional Sciences contacted study participants and completed 24-hour computer-assisted telephone interview recalls on 2 nonconsecutive days. The NDR subsequently produced a detailed reported that provides an estimate of total calorie and macronutrient intake. Of particular interest were daily kcals, % kcals from fat, protein, carbohydrates, and sweets as well as folate, iron, calcium, and zinc, as well as vitamins A, B1, B6, B12, D, E, and K. Surgery patients were instructed to take a daily multivitamin.[35] Those undergoing Roux-en-Y gastric bypass (RYGB) were prescribed calcium supplements. Girls undergoing RYGB were also prescribed iron supplements.

The Eating Inventory

The Eating Inventory (EI) is a 51-item self-report inventory that assesses three-factors: 1) Cognitive Restraint; 2) Disinhibition; and 3) Hunger. The inventory measures the degree to which persons exert conscious control over food intake and the extent to which internal or external factors disrupts such control.[36]

Eating Disorder Examination Questionnaire (EDE-Q)

The EDE-Q is a 41-item measure adapted from the Eating Disorder Examination interview.[37–39] The measure has good psychometric properties and adolescent norms. The EDE-Q consists of four subscales that address key aspects of eating disorder psychopathology: restraint, eating concern, shape concern, and weight concern. The eating concern subscale is an effective brief screening measure for BED.[39]

The Night Eating Questionnaire (NEQ)

The NEQ is a 14-item instrument assessing night eating behaviors.[40] Validity has been shown by positive relationships with sleep problems, eating disorder symptomatology, and depressive symptoms.[40–41]

The Food Craving Inventory (FCI)

The FCI measures the frequency of specific food cravings, such as fats, sweets, carbohydrates/starches, and fast food fats.[42] The FCI defines a craving as an intense desire to consume a particular food or type of food that is difficult to resist.

Statistical Analysis

Summary statistics (mean, standard deviation, 95% confidence intervals [CI]) and cross-tabulations (frequency, percentage) for participant demographic and baseline characteristics were calculated for the entire sample and by group. To assess whether the groups differed in terms of these characteristics, t-tests or the non-parametric Wilcoxon Rank Sum tests were conducted for continuous characteristics and Chi-square or Fisher's Exact test for categorical characteristics. Participant characteristics found to be significantly different between groups were adjusted for in subsequent statistical models.

The Results section details these adjustments

To examine postoperative changes in weight, macronutrients, vitamins, and eating behaviors, repeated measures mixed effects models were fit that included group (surgery, LM) as the between-subjects factor and time (changes from baseline to months 6 and 12) as the within-subjects factor.[43] Time was treated as categorical variable, which allowed for a comparison of group differences at each point. An unstructured variance covariance form in repeated measurements was assumed for each outcome. Model-based mean ± standard error (SE) values and between group p-values were reported for each outcome at each time point by group. In addition, mixed models were fit to assess changes within bariatric surgery group across all time points (changes from baseline to months 6, 12, and 24) but without the main effect of group. For all mixed models, sensitivity analyses were completed via fitting unadjusted models and models adjusted for characteristics that differed at baseline. Mixed effects models are most robust in the analysis of unbalanced data when compared to similar analyses.[44] With this approach, all data collected was used and without regard to whether data were missing for a patient at another visit. This includes data for individuals who withdrew from the study; explicit imputation of missing data was not performed. This analytic approach minimizes bias if individuals dropped out of the two groups for different reasons.

For the analyses within bariatric surgery patients, logistic regression models were fit to examine differences in outcomes between those patients who continued to lose weight between months 6 and 12 versus those who gained weight. Prior to fitting the logistic regression models, a binary outcome was created where "weight gain" was defined as percentage change in weight from baseline being greater than zero; "continued weight loss" was defined as percentage change from baseline being less than zero. From these models, odds ratios (ORs) with 95% CI and p-values were calculated. For the logistic regression

model, missing data for weight change between month 6 and 12 was not imputed. Sensitivity analyses were conducted to consider the effect of recoding missing data as staying the same or decreasing, versus effect of recoding the missing data as increase in weight. All analyses were conducted utilizing the statistical software package SAS, version 9.4 and statistical significance was set at alpha = 0.05. Due to the nature of these secondary and exploratory analyses, no adjustment for multiple testing was made.

Results

Participant Characteristics

Table 1 displays the demographic and descriptive variables for the entire sample and the two groups. Participants had a mean age of 16 ± 1.9 yrs, height of 166. ± 8.6 cm, weight of 120 ± 33.7 kg, and body mass index (BMI) of 43 ± 10.2 kg/m^2. The majority (76%) was female. Fifty-seven percent (57%) were White, 36% were Black, and the remainder were of other ethnic origin.

Baseline Comparisons between Surgery and LM Participants

There were several significant differences in the demographic characteristics between adolescents who underwent bariatric surgery and those treated with LM. Adolescents who presented for bariatric surgery were more likely to be older (17 ± 1.5 vs 15 ± 1.4 yrs, $p < 0.01$), White (72% vs. 47% White, $p < 0.01$), have a higher baseline BMI (52 ± 8.9 vs. 37 ± 5.2 kg/m^2, $p < 0.01$), and have parents with a higher level of education (18% with some college or more vs. 9%). All subsequent comparisons between the two groups were adjusted for these differences (Tables 2 through 4) as described above.

Table 2 displays the macronutrient intake variables at baseline. Patients awaiting bariatric surgery reported eating significantly less kcal/d than those about to begin LM (1053.0 ± 423.0 vs. 1505.2 ± 486.3 kcal/d, $p < .001$). Patients awaiting surgery reported higher intake of protein (22.7 ± 6.7 vs 17.2 ± 4.3, $p<0.001$), calcium (871.7 ± 513.2 vs. 652.9 ± 300.2, $p <0.001$, vitamin D (5.2 ± 3.3 vs. 3.3 ± 2.4, $p < 0.001$) and vitamin E (9.1 ± 9.1 vs. 4.9 ± 2.8, $p < 0.001$) as well as a lower intake of fat (26.8 ± 9.5 vs. 32.9 ± 6.0, $p < 0.001$) and vitamin B1(1.2 ± 0.5 vs. 1.3 ± 0.5, $p < 0.01$).

There also were significant differences in eating behaviors between the two groups (Table 2). Surgery candidates reported significantly greater symptoms of disordered eating, with a significantly higher global score on the EDE-Q, and higher scores on the restraint, a concern subscales. Surgery candidates also endorsed significantly higher levels of cognitive restraint and hunger as assessed by the EI. They also reported more symptoms of disordered eating on the NEQ.

Changes in Weight

At baseline, there were 169 adolescents preparing to start LM and 119 preparing for bariatric surgery; at 6 months, there were 110 and 102 weights measured, respectively in each group and at 12 months, 117 and 109, respectively. At both 6 and 12 months after surgery or the onset of LM, adolescents who underwent surgery lost significantly more weight than those

treated with LM (Table 3). Surgery patients lost 26.1 ± 1.0% of their weight at 6 months and 31.63 ± 1.0% at 12 months, compared to weight losses of 2.5 ± 1.1% and 0.2 ± 0.9% in those treated with LM (each $p < 0.0001$). Participants treated with LM experienced a statistically significant increase in height over the year. However, the change in absolute weight, BMI, and percent weight loss were similar (Table 3).

Changes in Dietary Intake

Both groups reported a decrease in energy intake with treatment. While adolescents who underwent surgery reported larger decreases in caloric intake, the magnitude of change compared to that seen with adolescents treated with LM did not reach statistical significance. Adolescents who underwent surgery, as compared to those treated with LM, reported significant reductions in the intake of calcium, iron, folate, and vitamins A and D at both 6 and 12 months postoperatively (Table 3).

Eating Behavior

Patients who underwent surgery, compared to those treated with LM, reported significantly greater reductions in disordered eating symptoms, as assessed by the global score of the EDE-Q, as well as the restraint, and shape and weight concern subscales, at both 6 and 12 Months (Table 4). Surgery patients also reported significant reductions in cognitive restraint as assessed by the EI at 6 and 12 months. Changes over time in the two groups did not differ on the other measures.

Changes in Weight for Surgery Patients to Postoperative Month 24

Patients, on average, lost the largest amount of their weight in the first 6 months after surgery and lost an additional 5% of their weight from month 6 to 12. From month 12 to 24, weight remained largely unchanged (Figure 1).

In a post-hoc manner, we performed a logistic regression analysis to explore how changes in dietary intake and eating behavior predicted the binary outcome of continued weight loss or gain (from month 6 to 24). This analysis suggested that self-reported intake of zinc was significantly associated with weight loss. The analysis also found that changes on the weight concern subscale of the EDE-Q and the sweets subscale of the FCI were significant predictors of change in weight. Within the logistic regression model, a one-unit decrease in the consumption of zinc at month 6 increased the odds of regaining weight between month 6 and 24 by 1.27 times ($p < 0.05$). A one-unit increase on the weight concern subscale increased the odds of gaining weight from month 6 to 24 by 1.53 times ($p < .04$). A one-unit increase in the mean craving for sweets increased the odds of gaining weight by 2.38 times ($p < 0.01$). (A sensitivity analyses performed with recoding of missing data provided analogous results. These results are not shown.)

Discussion

This study provides new information on changes in dietary intake and eating behavior of adolescents who underwent bariatric surgery. Adolescents who presented for bariatric surgery endorsed greater symptoms of disordered eating across multiple validated

psychometric measures than those presenting for treatment with LM. However, adolescents presenting for surgery also reported consuming fewer total kcal/d, and fewer grams of fat, but greater amounts of protein and a number of vitamins and minerals than those about to start a LM program. Patients who underwent bariatric surgery reported significantly greater weight losses as well as greater positive changes in many disordered eating symptoms than those treated with LM. Self-reported cravings for sweets and concerns about weight, along with consumption of zinc, were associated with weight loss at the end of the second postoperative year.

Adolescents preparing for surgery reported eating approximately 1,050 kcal/d, an energy intake inconsistent with the development of obesity, and approximately 500 kcal lower than reported by adolescents who were less obese and starting a LM intervention for weight loss. These observations are surprising and are at odds with clinical experience. Studies of adults have suggested that candidates for bariatric surgery report consuming at least 2,400 kcal/d and as much as 4,000 kcal/d.[16, 45] According to NHANES data from 2005–2006, children and adolescents between the ages of 14–18 years have a mean caloric intake of 2,427 calories per day.[46] Adolescents in the present study, with a mean BMI of 43 kg/m^2, reported eating approximately 1,000 kcal/d fewer. The self-reported intake of adolescents preparing for surgery may reflect their participation in a preoperative medical weight management program. Teen-LABS sites encouraged participants to work with dietitians for several months prior to surgery, consistent with accepted standards of care for adolescent bariatric surgery.[33,47] However, this preoperative counseling was not standardized across study sites, limiting the ability to draw more firm conclusions from these observations.

One year after bariatric surgery, adolescents lost approximately 31.6% of their initial body weight. Adolescents treated with LM lost 0.3% of their initial weight. Both of these observations are largely consistent with previous studies. While those adolescents who underwent surgery reported larger decrease in total energy intake, the magnitude of the decrease, compared to those treated with LM, did not reach statistical significance. At month 6, the difference approached significance and, thus, may account for the substantial weight loss seen in that period of time. However, at month 12, the difference between the groups is approximately 40 kcal/d on average. This finding is counterintuitive and has several possible explanations.

The lack of correspondence between changes in weight and self-reported changes in caloric intake may, at least in part, be a function of the validity of self-reported dietary intake in adolescents, even when assessed with tools such as the NDR.[48–51] Ventura and colleagues, for example, described patterns of bias in self-reported dietary recall data of pre-adolescent girls. Participants were divided into three samples; under-reporters, plausible reporters, and over-reporters. The mean weight of girls classified as under-reporters was significantly higher than that of the plausible reporters and over reporters.[51] These two factors participation in preoperative medical weight management and concerns about the validity of the self-reports of dietary intake may explain the relatively few statistically significant differences in energy and macronutrient intake between the two treatment groups.

These observations also open the door to the consideration of the role of other physiological mechanisms in outcomes of bariatric surgery. More specifically, it may be that other possible mechanisms such as energy expenditure or differential changes in absorption or metabolism of nutrients, rather than reduction in caloric intake, produce weight loss. Some, but not all, studies have documented reductions in both total and resting energy expenditure following bariatric surgery.[52] Unfortunately, we were unable to study changes in metabolism or physical activity in the current study.

Adolescents who presented for bariatric surgery reported greater symptoms of disordered eating compared to those who were less obese and about to begin a LM program. High rates of self-reported symptoms of disordered eating have been found in other studies of adolescent bariatric surgery candidates.[25] Encouragingly, adolescents who underwent surgery reported significantly greater reductions in features of disordered eating over the first postoperative year and as compared to adolescents who received LM. These results are similar to those seen with adults who undergo bariatric surgery.[16,53] Adolescents who underwent bariatric surgery also reported greater reductions in weight and shape concerns. Individuals who undergo bariatric surgery typically report large improvements body image prior to reaching maximum weight loss. These changes are well maintained through the first several postoperative years.[11,16,54–56] Adolescents who underwent surgery reported significant reductions in the intake of calcium, iron, folate, iron, zinc, and vitamins A and D at both 6 and 12 months postoperatively. Given the concerns about self-reported dietary intake, these observations must be viewed with caution. Adolescents who underwent surgery were instructed to take daily multivitamins, although adherence was not assessed. The differences between the groups are unlikely to be due to supplements, however, as there was no difference in B6, or vitamins E or K.

Among adolescents who underwent surgery, select variables were associated with weight loss by the second postoperative year. An increase in concerns about weight and increased cravings for sweets predicted weight gain from month 6 to 24. These changes suggest the development of maladaptive thoughts about food intake that could contribute to weight gain. Zinc is considered part of a healthy diet and the mineral is found in large concentration in meats, fish, beans and other sources of protein.[57] There has been little research on the relationship of dietary zinc to obesity and weight loss. In at least one study, elevated levels of zinc, measured biochemically, have been observed in women who have lost weight with a hypocaloric diet.[58] By contrast, the results here suggest that increased self-reported consumption of zinc was associated with weight regain from postoperative month 6 to 24.

The study had several limitations. Our two groups differed in age, race, gender and BMI. Since the start of this study, a number of investigations have raised concerns about the accuracy and validity of information that adolescents provide in these interviews, as noted above.[48–51] We also experienced some attrition. While this did not appear to be systematic, it may have biased the results.

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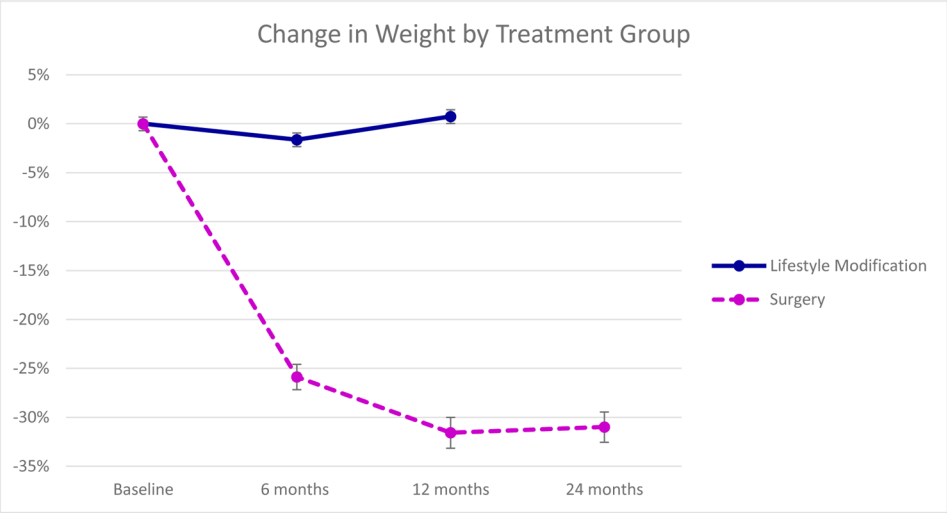

Figure 1.

Table 1

Demographic, Anthropometric, and Procedural Characteristics of All Participants at Baseline

Characteristic	All Participants (N=288) % or Mean ± SD	Lifestyle Modification (N=169) % or Mean ± SD	Surgery (N=119) % or Mean ± SD
Age-yr *	16 ± 1.9	15 ± 1.4	17 ± 1.5
Age group-no. (%)			
12–15 yr	167 (58)	135 (80)	32 (27)
16–17 yr	84 (29)	34 (20)	50 (42)
18–20 yr	37 (13)	0	37 (31)
Sex no (%)			
Female	219 (76)	130 (77)	89 (75)
Male	69 (24)	39 (23)	30 (25)
Race or ethnic background no. (%) *			
White	165 (57)	79 (47)	86 (72)
Black	105 (36)	79 (47)	26 (22)
More than one race or ethnic background	16 (6)	9 (5)	7 (6)
Parental Caregiver Level of Education no (%) *			
High School or Less	104 (37)	55 (33)	49 (43)
Some College	143 (50)	98 (58)	45 (39)
College or More	37 (13)	16 (9)	21 (18)
Mean weight (95% CI) *			
Baseline-kg	120 *± 33.7*	101 *± 18.9*	147 *± 30.9*
Mean height (95% CI)			
Baseline-cm	166 *± 8.6*	165 *± 7.6*	168 *± 9.7*
Mean BMI (95% CI) *			
Baseline	43 *± 10.2*	37 *± 5.2*	52 *± 8.9*

* Indicates variables that were significantly different between control and surgery patients at baseline.

Table 2

Macronutrient Intake and Eating Behavior Variables at Baseline

Variable	*Lifestyle Modification Mean ± SD*	*Surgery Mean ± SD*
Macronutrient Intake		
Energy (kcal) ***	1505.2 ± 486.3	1053.0 ± 423.0
Carbohydrates (g)	50.0 ± 7.0	50.6 ± 9.5
Fat (g) ***	32.9 ± 6.0	26.8 ± 9.5
Protein (g) ***	17.2 ± 4.3	22.7 ± 6.7
Sugar (g) ^	22.3 ± 6.2	26.2 ± 13.2
Calcium (mg) ***	652.9 ± 300.2	871.7 ±513.2
Folate (mcg)	298.3 ± 122.0	276.0 ± 115.7
Iron (mg) *	11.4 ± 4.2	10.4 ± 4.9
Zinc (mg)	8.1 ± 3.4	8.4 ± 4.0
Vitamin A (mcg)	3681.2 ± 3103.4	4454.0 ± 3373.1
Vitamin B1 (mg) **	1.3 ± 0.5	1.2 ± 0.5
Vitamin B6 (mg)	1.4 ± 0.5	1.5 ± 0.8
Vitamin B12 (mcg)	3.7 ± 2.1	4.3 ± 2.2
Vitamin D (mcg) ***	3.3 ± 2.4	5.2 ± 3.3
Vitamin E (mg) ***	4.9 ± 2.8	9.1 ± 9.1
Vitamin K (mcg)	73. ± 81.7	59.1 ± 50.6
Eating Behavior		
Eating Disorder Examination Questionnaire		
Restraint *	1.8 ± 1.1	2.3 ± 1.4
Eating Concern	1.2 ± 1.2	1.6 ± 1.3
Shape Concern *	2.9 ± 1.5	3.5 ± 1.5
Weight Concern *	2.6 ± 1.1	3.1 ± 1.2
Global Score **	2.1 ± 1.0	2.6 ± 1.1
Food Craving Inventory		
Fat	2.0 ±0.8	2.2 ± 0.7
Sweet	2.5 ±0.8	2.3 ± 0.8
Carbohydrates	2.1 ± 0.7	2.3 ± 0.8
Fast Food	2.7 ± 0.9	2.8 ± 0.9
Total	2.3 ± 0.7	2.3 ± 0.6
Eating Inventory		
Cognitive Restraint **	8.3 ± 3.2	10.2 3.8
Disinhibition	4.7 ± 2.9	6.3 ± 3.6
Hunger *	5.1 ± 3.5	6.3 ± 3.7

Variable	*Lifestyle Modification Mean ± SD*	*Surgery Mean ± SD*
Night Eating Questionnaire		
Total**	11.2 ± 7.1	16.7 ± 8.2

* Significant at p = 0.05;

** Significant at p = 0.01;

*** Significant at p <0.001

^ A log transformation was used on baseline calories from sugar to adjust for outliers and distribution

Table 3

Postoperative Changes in Weight, Macronutrients and Vitamins *

Variable	*Lifestyle Modification Mean ± SE*	*Surgery Mean ± SE*	Between Group p-value
Percentage Change in Weight			
At month 6	−2.5 ± 0.8	−26.1 ± 0.8	<0.0001
At month 12	−0.3 ± 0.9	−31.6 ± 1.0	<0.0001
Change in Weight (kg)			
At month 6	−6.1 ± 1.1	−34.5 ± 1.1	<0.0001
At month 12	−3.8 ± 1.3	−43.1 ± 1.4	<0.0001
Change in Height			
At month 6	0.4 ± 0.2	0.1 ± 0.2	0.3367
At month 12	1.2 ± 0.2	0.2 ± 0.2	0.0017
Change in BMI			
At month 6	−1.9 ± 0.4	−12.6 ± 0.4	<0.0001
At month 12	−1.4 ± 0.4	−15.5 ± 0.5	<0.0001
Energy (kcal)			
At month 6	−124.8 ± 66.9	−329.8 ± 91.0	0.0625
At month 12	−137.7 ± 68.0	−180.4 ± 96.1	0.7103
Change in Carbohydrates (g)			
At month 6	−1.2 ± 1.4	−5.0 ± 1.9	0.1051
At month 12	0.2 ± 1.4	−3.0 ± 1.9	0.1648
Change in Fat (g)			
At month 6	0.9 ± 1.2	2.0 ± 1.6	0.5722
At month 12	−0.2 ± 1.2	2.7 ± 1.7	0.1678
Change in Protein (g)			
At month 6	0.2 ± 0.9	2.8 ± 1.3	0.0935
At month 12	−0.2 ± 0.9	0.2 ± 1.3	0.7975
Change in Sugar (g)			
At month 6	−1.3 ± 1.4	−5.7 ± 2.0	0.0609
At month 12	−1.5 ± 1.5	−3.1 ± 2.1	0.5187
Change in Calcium (mg)			
At month 6	−29.5 ± 53.0	−233.4 ± 72.3	0.0202
At month 12	−24.5 ± 52.1	−208.8 ± 73.8	0.0387
Change in Folate (mcg)			
At month 6	3.7 ± 18.2	−85.6 ± 24.7	0.0030
At month 12	1.9 ± 19.0	−75.0 ± 27.1	0.0187
Change in Iron (mg)			
At month 6	0.3 ± 0.7	−3.5 ± 0.1	0.0014
At month 12	−0.1 ± 0.7	−3.5 ± 1.0	0.0014

Variable	*Lifestyle Modification Mean ± SE*	*Surgery Mean ± SE*	Between Group p-value
Change in Zinc (mg)			
At month 6	−0.0 ± 0.6	−2.7 ± 0.8	0.0064
At month 12	−0.7 ± 0.6	−2.5 ± 0.8	0.0726
Change in Vitamin A (mcg)			
At month 6	671.6 ± 531.9	−1719.7 ± 724.9	0.0070
At month 12	1167.6 ± 534.2	−1846.0 ± 767.6	0.0013
Change in Vitamin B1 (mg)			
At month 6	−0.1 ± 0.0	−0.3 ± 0.1	0.0666
At month 12	−0.1 ± 0.0	−0.2 ± 0.1	0.2601
Change in Vitamin B6 (mg)			
At month 6	−0.0 ± 0.1	−0.3 ± 0.1	0.1901
At month 12	−0.1 ± 0.1	−0.3 ± 0.1	0.2425
Change in Vitamin B12 (mcg)			
At month 6	0.1 ± 0.3	−1.0 ± 0.5	0.0423
At month 12	−0.4 ± 0.3	−1.2 ± 0.5	0.1717
Change in Vitamin D (mcg)			
At month 6	0.0 ± 0.4	−2.0 ± 0.6	0.0037
At month 12	−0.2 ± 0.4	−1.7 ± 0.6	0.0425
Change in Vitamin E (mg)			
At month 6	−0.6 ± 0.9	−2.61 ± 1.2	0.1597
At month 12	−0.4 ± 0.9	−2.61 ± 1.2	0.1150
Change in Vitamin K (mcg)			
At month 6	−1.7 ± 12.3	−33.8 ± 16.8	0.1130
At month 12	10.6 ± 13.6	−26.1 ± 19.4	0.1149

*Adjusted for age, weight, parent education, and race

Table 4

Postoperative Changes in Eating Behavior (Absolute Change)*

Variable	*Lifestyle Modification Mean ± SE*	*Surgery Mean ± SE*	Between Group p-value
Eating Disorder Examination Questionnaire			
Restraint			
At month 6	0.7 ± 0.4	−0.3 ± 0.3	0.0361
At month 12	0.4 ± 0.4	−0.6 ± 0.3	0.0169
Eating Concern			
At month 6	−0.7 ± 0.3	−0.7 ± 0.2	0.2506
At month 12	−0.2 ± 0.3	−0.8 ± 0.2	0.0930
Shape Concern			
At month 6	−0.2 ± 0.3	−1.0 ± 0.2	0.0307
At month 12	−0.4 ± 0.3	−1.2 ± 0.2	0.0281
Weight Concern			
At month 6	−0.3 ± 0.3	−1.0 ± 0.2	0.0202
At month 12	−0.1 ± 0.3	−1.3 ± 0.2	0.0012
Global Score			
At month 6	−0.0 ± 0.3	−0.8 ± 0.2	0.0091
At month 12	−0.0 ± 0.3	−1.0 ± 0.2	0.0017
Food Craving Inventory			
Fat			
At month 6	−0.2 ± 0.2	−0.4 ± 0.1	0.3449
At month 12	−0.2 ± 0.2	−0.4 ± 0.1	0.3481
Sweets			
At month 6	−0.1 ± 0.2	−0.4 ± 0.1	0.1592
At month 12	− 0.1 ± 0.2	−0.2 ± 0.1	0.4951
Carbohydrates			
At month 6	−0.2 ± 0.2	−0.6 ± 0.1	0.1282
At month 12	−0.2 ± 0.2	−0.4 ± 0.1	0.2064
Fast Food			
At month 6	−0.3 ± 0.2	−0.6 ± 0.1	0.2018
At month 12	−0.3 ± 0.2	−0.4 ± 0.1	0.7216
Total Score			
At month 6	−0.2 ± 0.6	−0.5 ± 0.1	0.1217
At month 12	−0.2 ± 0.1	−0.4 ± 0.1	0.3055
Eating Inventory			
Cognitive Restraint			
At month 6	2.7 ± 0.9	−0.7 ± 0.6	0.0017
At month 12	2.5 ± 0.9	−1.1 ± 0.6	0.0008

Variable	*Lifestyle Modification Mean ± SE*	*Surgery Mean ± SE*	Between Group p-value
Disinhibition			
At month 6	−0.4 ± 0.8	−2.0 ± 0.5	0.0731
At month 12	−0.9 ± 0.8	−2.1 ± 0.5	0.1730
Hunger			
At month 6	−0.9 ± 0.8	−2.2 ± 0.5	0.1667
At month 12	−0.8 ± 0.8	−2.3 ± 0.5	0.0931
Night Eating Questionnaire			
Total			
At month 6	−3.2 ± 3.7	0.3 ± 3.1	0.3755
At month 12	−1.6 ± 4.1	1.7 ± 3.5	0.4763

*Adjusted for age, weight, parent education, and race