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ORIGINAL CONTRIBUTIONS

Changes in Eating Behaviors and Their Relation to Weight Change 6 and 12 Months After Bariatric Surgery

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Abstract

Introduction Identifying eating behaviors associated with suboptimal weight loss following bariatric surgery remains important. This study assessed the relationship between eating behaviors and weight loss following bariatric surgery in a racially diverse sample.

Methods Participants were assessed before surgery and 6 and 12 months postoperatively, with the Structured Clinical Interview for DSM-5, the Eating Disorder Examination-Bariatric Surgery Version, and validated measures assessing a range of eating behaviors. Linear mixed effect models were used to test the impact of eating behaviors on percent weight loss (%WL) at 6 and 12 months.

Results We enrolled 300 participants (mean age 40.1 years; BMI 45.9 kg/m^2; 87% women; 62% Black and 30% White). The majority (82%) underwent sleeve gastrectomy (SG). Mean %WL was 23.0 ± 5.1% at 6 months and 26.2 ± 7.6% at 12 months. Subjective binge episodes prior to surgery predicted greater %WL over the first 12 postoperative months ($p = 0.028$). Postoperative disinhibition, hunger, night eating symptoms, objective binge episodes, global disordered eating attitudes and behaviors, and snacks per day were associated with smaller %WL over 12 months (all *p's* < 0.01). The presence of picking/nibbling and addictive-like eating behaviors was not associated with %WL at the end of the first postoperative year.

Conclusion Among a diverse participant sample, problematic eating behaviors following surgery were associated with smaller %WL over 12 months. Postoperative assessment and treatment of eating behaviors are needed to address these issues as they arise and to prevent attenuation of early weight loss in some patients.

Keywords Eating behavior · Postoperative outcomes · Binge eating disorder · Night eating syndrome · Bulimia nervosa · Bariatric surgery

Introduction

Bariatric surgery remains the most effective and durable treatment for obesity. However, most individuals regain some weight [1]. In the longitudinal assessment of bariatric surgery (LABS) study, for example, the average weight gain between years 3 and 7 after surgery was 3.9% of baseline weight, with degree of variability increasing over time [2].

Problematic eating behaviors can attenuate weight losses or promote weight regain [3]. These behaviors include experiencing a loss of control (LOC) over eating, picking and nibbling food throughout the day, feeling disinhibited when eating, increased hunger, and emotional eating. None of these variables, when measured prior to surgery, has emerged as consistent predictors of postoperative weight loss [4–6]. More consistently, problematic eating behaviors *after* surgery, whether de novo or recurrent, seem to be associated with smaller postoperative weight loss [7–12].

Fewer studies have examined the prospective role of night eating behaviors or addictive-like eating behavior in outcomes of bariatric surgery. The presence of night eating symptoms after surgery, for example, was recently associated

Key Points

- Postoperative eating behaviors are related to lower %WL in a racially diverse sample.
- Disinhibition, hunger, snacking, and eating behaviors were associated with lower %WL.
- Subjective binge episodes before surgery predicted greater %WL.
- Addictive-like eating, picking/nibbling, and meal frequency were not related to %WL.

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with smaller weight loss outcomes [13]. However, studies of addictive-like eating behavior, a constellation of disordered eating symptoms focused on cravings to eat highly processed foods, have yet to be consistently associated with weight loss [14, 15].

Many previous studies of these behaviors have relied on patient-reported outcome measures as opposed to empirically supported structured diagnostic interviews [3]. Others have used information obtained in preoperative clinical assessments, when participants may minimize disordered eating symptoms in order to be approved for surgery, as opposed to independent evaluations [16]. Few studies have investigated problematic eating among patients who underwent sleeve gastrectomy (SG), which is now the most common bariatric procedure in the USA [17]. Finally, most studies have included a majority of non-Hispanic, White patients; it is unclear if the observations are generalizable to additional racial/ethnic groups.

This study investigated the association of problematic eating behaviors with weight loss outcomes at 6 and 12 months following bariatric surgery in a racially and ethnically diverse sample. We hypothesized that the presence of problematic eating behavior would be related to smaller percent weight loss (%WL) in the first postoperative year.

Method

Participants

Participants included 300 individuals who sought bariatric surgery at the University of Pennsylvania and Temple University Health Systems. Details of the recruitment strategy, inclusion criteria, and demographic variables were reported elsewhere [18]. The original sample consisted of 260 women (87%) and 40 men (13%), with a mean age of 40.05 ± 11.03 years and a body mass index (BMI) of 45.87 ± 6.24 kg/m^2 [18]. The majority self-identified as Black (62%), with 30% identifying as White, 4% more than one race, and 4% additional race group. Additionally, 9% identified as Hispanic or Latino. Equal percentages (42%) were single or married. Almost two-thirds (62%) reported full-time employment, and a third (33%) had at least a college degree.

Overall, 281 participants underwent surgery. Of these, 245 underwent SG and 36 Roux-en-Y gastric bypass (RYGB). At 6 and 12 months postoperatively, 218 (78%) and 193 participants (69%), respectively, completed at least part of the assessment (all were completed in person before COVID-19 pandemic restrictions). There were no appreciable differences in baseline demographics at either time point (see Table 1, Fig. 1). We also examined baseline differences between those who did not complete any assessment visits after baseline with those who did and found that non-completers ate fewer meals on average ($p = 0.01$) and reporter lower cognitive restraint over eating ($p = 0.04$) than those with at least one follow-up assessment. However, no differences were noted on disordered eating measures. The number of participants who completed each interview and survey varied (see Table 2). The Institutional Review Boards at both institutions approved the study, and we registered it under clinicaltrials.gov (NCT02775071). All participants provided informed consent.

Table 1 Demographic characteristics of the sample at baseline

	n (%) or mean ± SD
Gender	
Women	260 (87)
Men	40 (13)
Race (*n* = 291)	
Black or African American	179 (62)
White	87 (30)
Additional responses (including more than one race)	25 (8)
Age (years)	40.05 ± 11.03
BMI (kg/m^2)	45.87 ± 6.24
Education (*n* = 296)	
Some junior high school	3 (1)
Some high school	10 (3.4)
High school graduate or GED	58 (19.6)
Post high school training (not college)	29 (9.8)
Some college	96 (32.4)
College graduate	51 (17.2)
Postgraduate work	49 (16.6)
Marital status (*n* = 296)	
Married or living as married	125 (42.2)
Single, never married	124 (41.9)
Separated	13 (4.4)
Divorced	26 (8.8)
Widowed	8 (2.7)
Employment status (*n* = 296)	
Working full time	183 (61.8)
Working part time	30 (10.1)
Unable to work	25 (8.5)
Home keeper/stay at home mother	20 (6.8)
Unemployed, looking for work	16 (5.4)
Unemployed, not looking for work	10 (3.4)
Student	12 (4.1)
Surgery type	
Sleeve gastrectomy	245 (81.7)
Roux-en-Y gastric bypass	36 (12)
Did not undergo surgery	19 (6.3)

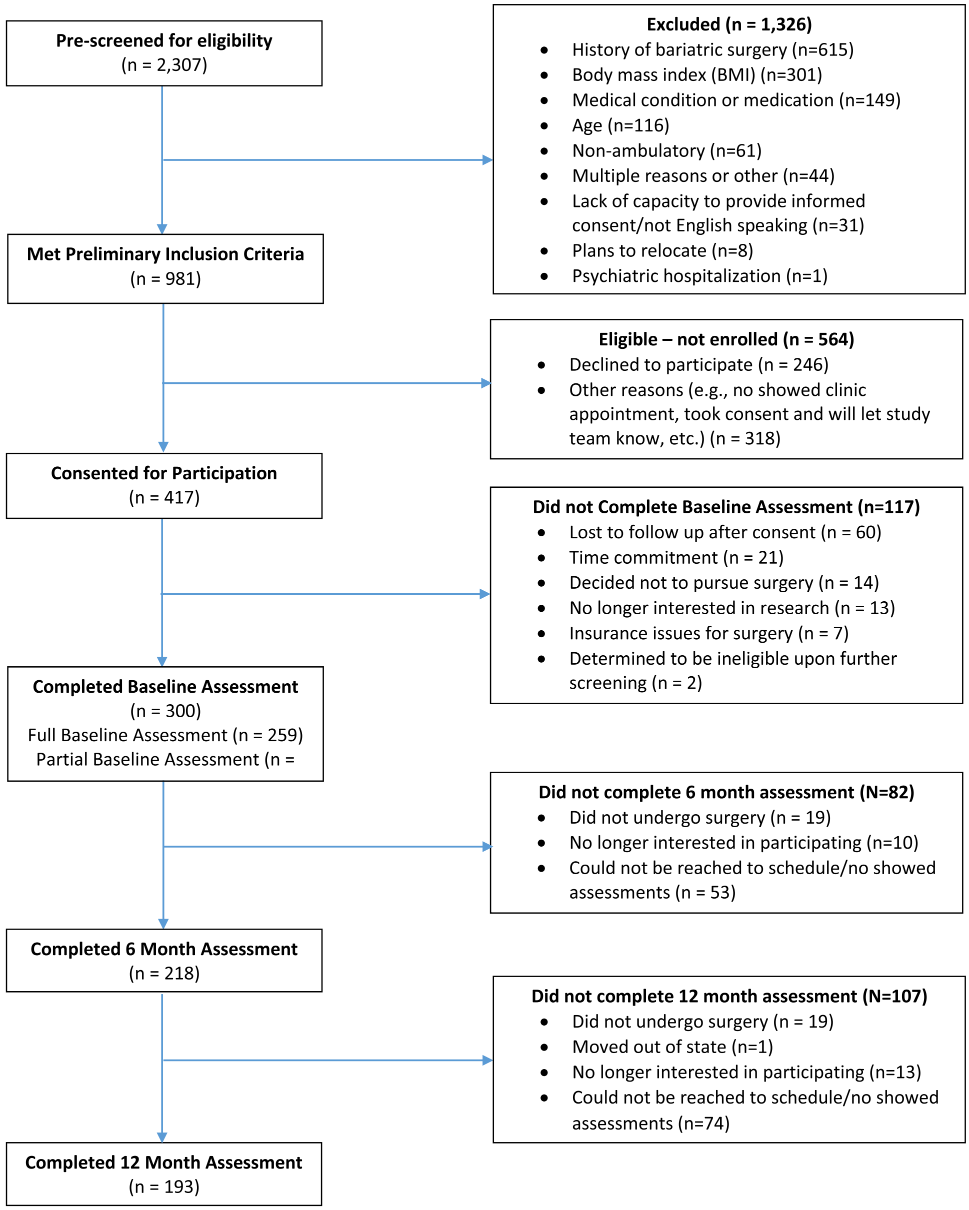

Fig. 1 CONSORT diagram for participant recruitment, participation and retention

Measures

Participants completed the following assessments approximately 4 weeks before surgery, and we scheduled them to complete them again 6 and 12 months postoperatively. We described the measures in detail previously [18] and briefly summarize them here.

We used the *Structured Clinical Interview for the DSM-5, Research Version* (SCID-5-RV) [19] to establish a lifetime history of eating disorder diagnoses. We also interviewed participants with the *Eating Disorder Examination-Bariatric Surgery Version* (EDE-BSV) [20] to generate scores for restraint, eating concern, weight concern, shape concern, and the global score. We also averaged the frequency of objective binge episodes (OBEs) and subjective binge episodes (SBEs) over the past 6 months at each assessment point. We coded the presence of any self-reported OBE or SBE episodes as *yes* or *no* in the longitudinal models. Finally, we added items to the EDE to fully assess diagnostic criteria for night eating syndrome (NES) [20].

We used three self-reported measures to assess eating behaviors. The *Eating Inventory* (EI) [21] measured cognitive restraint, disinhibition, and hunger. The *Night Eating Questionnaire* (NEQ) [22] screened for symptoms of NES. The *Yale Food Addiction Scale* (YFAS) [23] identified those who were using high sugar/high fat foods in ways similar to symptoms of substance use such as experiencing withdrawal symptoms or a continued desire or unsuccessful attempts to stop eating these foods. Those who endorsed 3 or more symptoms and who reported distress and/or impairment were considered to have "food addiction."

Table 2 Means (SD) or *n* (%) or percent changes in weight and disordered eating characteristics at baseline, 6 and 12 months

Variable	Baseline ($N=271–298$)[1]	6 months ($N=208–216$)[1]	12 months ($N=186–224$)[1]
Weight			
Weight (kg)	127.68 (22.29)	97.79 (18.04)	93.77 (19.62)
% weight loss (total sample)	N/A	22.97 (5.11)	26.23 (7.71)
% weight loss RYGB		24.81 (4.20)	29.82 (6.08)
% weight loss SG		22.72 (5.18)	25.78 (7.72)
Eating Disorder Examination–Bariatric Surgery Version			
Global	1.63 (0.77)	0.92 (0.67)	0.96 (0.74)
Restraint	2.04 (1.14)	1.31 (1.16)	1.27 (1.19)
Eating concern	0.39 (0.67)	0.25 (0.47)	0.20 (0.39)
Weight concern	1.92 (1.11)	1.15 (1.00)	1.18 (1.06)
Shape concern	2.20 (1.36)	0.98 (0.95)	1.18 (1.14)
Mean objective binge episodes (past 28 days)	0.93 (3.98)	0.02 (0.15)	0.18 (1.27)
Number with any objective binge episodes:			
Yes	30 (11.2)	4 (1.9)	8 (4.3)
No	238 (88.8)	203 (98.1)	178 (95.7)
Mean subjective binge episodes (past 28 days)	0.17 (1.18)	0.04 (0.24)	0.08 (0.55)
Number with any subjective binge episodes:			
Yes	12 (4.4)	9 (4.4)	4 (2.2)
No	258 (95.6)	198 (95.6)	182 (97.8)
Picking and nibbling	2.97 (5.99)	3.06 (6.58)	3.68 (7.33)
Average number of meals/day	2.35 (0.59)	2.64 (0.48)	2.61 (0.50)
Average number of snacks/day	2.13 (1.70)	1.60 (1.11)	1.69 (1.09)
Eating Inventory			
Cognitive restraint	9.23 (3.65)	11.26 (3.50)	10.64 (3.96)
Disinhibition	5.79 (3.26)	2.90 (2.46)	3.22 (2.52)
Hunger	4.31 (3.37)	1.61 (2.01)	1.93 (2.26)
Night Eating Questionnaire			
Total	13.55 (6.57)	10.84 (5.51)	11.70 (6.53)
Yale Food Addiction Scale			
Symptom count	2.08 (1.44)	1.42 (1.12)	1.30 (1.03)

SD, standard deviation; *kg*, kilograms; *RYGB*, laparoscopic Roux-en-Y gastric bypass procedure; *SG*, laparoscopic sleeve gastrectomy procedure

[1]The number of participants with weights at 6 months was $n=245$ and at 12 months was $n=224$ due to data extraction from electronic medical records. The number of participants who completed the surveys and interviews at each time point are represented in the ranges for each column out of a possible $n=281$ participants who completed the surgery process

We measured weight measured with a calibrated digital scale with participants dressed in light clothing and without shoes. We calculated percent weight loss from participants' current weight in relation to their baseline weight. If a participant did not complete a study visit, weight was collected from their electronic medical record if they had attended a clinical appointment 1 month before or after they were scheduled to complete a study follow-up assessment.

Analytic Plan

We performed longitudinal data analysis with a series of linear mixed effect models to test the impact of eating behavior variables on the %WL at months 6 and 12. Two separate models were fit, one evaluated the association between baseline eating behavior on %WL over time; the other evaluated the association between postoperative eating behavior on %WL over time. In each model, each individual participant was treated as a random effect to account for the correlations among measurement of %WL over time; each eating behavior variable and time (6 or 12 months) was considered fixed effects. In all models, age, gender, race (White, Black, additional racial/ethnic groups), surgery type (SG or RYGB), and baseline BMI were adjusted as covariates. We evaluated the interaction term between each eating behavior and time first; if not significant, a main effect model with each eating behavior variable was reported by regression coefficient and its 95% confidence interval. We performed all analyses using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina), with statistical significance at $p<0.05$.

Results

Participants who did not undergo surgery were not included in further analyses ($n=19$, 6.3%). We also examined baseline differences between those who did not complete any assessment visits after baseline with those who did and found that non-completers ate fewer meals on average ($p=0.01$) and reporter lower cognitive restraint over eating ($p=0.04$) than those with at least one follow-up assessment. However, there were no differences on disordered eating measures.

Mean percent (standard deviation) weight loss from baseline was 23.0 (5.1)% at 6 months and 26.2 (7.6)% at 12 months (see Table 2). Percent total weight loss did not vary between White and Black participants, by sex, or in relation to baseline BMI.

Change in Eating Disorder Status Over Time

Binge Eating Disorder

Of the 268 participants who completed the EDE and SCID at baseline, 28 (10.5%) had a lifetime history of BED, including 18 (6.7%) who met BED criteria currently. Eighteen of the 28 individuals with lifetime or current BED at baseline completed the EDE at postoperative month 6. Of those, 14 participants were in remission, and 4 participants now met subthreshold criteria for BED. Of the 208 participants completing the EDE at 6 months, there was one new case of subthreshold BED. No participants met full diagnostic criteria for BED.

Twelve months after surgery, 186 completed the EDE. Of those 28 with lifetime or current BED at baseline, 17 completed the EDE. Of those, 11 individuals were in remission, 4 met subthreshold criteria, and 2 met diagnostic criteria for BED. The subthreshold case of BED at 6 months was in remission at 12 months.

Bulimia Nervosa

At baseline, 6 of the 268 participants had a lifetime history of bulimia nervosa (BN), and 2 had current BN. Five were in remission at 6 months, and 3 were in remission at 12 months. The remaining participants who met criteria at baseline ($n=1$ at 6 months and $n=3$ at 12 months) did not complete these postoperative assessments. Of the 208 participants at 6 months and 186 participants at 12 months who completed the EDE, no new cases of BN were diagnosed postoperatively.

Night Eating Syndrome

At baseline, NES was diagnosed in nine of the 268 participants; six individuals had subthreshold symptoms. At postoperative month 6 ($n=208$), one participant was diagnosed with NES, and six individuals had subthreshold symptoms; three of these subthreshold cases were new diagnoses. Four who met full criteria at baseline and five who had subthreshold symptoms were in remission at 6 months. Two participants who met full criteria for NES at baseline had subthreshold symptoms and one who met full criteria for NES at baseline continued to meet full criteria for NES at 6 months. The remaining two participants did not complete an assessment at six months.

At 12 months ($n=186$), there was one new diagnosis of NES and three new subthreshold cases. Five participants with NES at baseline and 4 with subthreshold symptoms were in remission. Two individuals with NES prior to surgery, and one with subthreshold symptoms, met subthreshold criteria at 12 months. Three participants who met threshold or subthreshold criteria at baseline did not complete the assessment at 12 months. Of the three new subthreshold cases at six months, two remained subthreshold, and one was in remission at 12 months.

Addictive-Like Eating Behavior

Prior to surgery, 21 of the 289 participants who completed the YFAS met criteria for addictive-like eating. At 6 months ($n=215$), two continued to meet criteria for "food addiction," and 13 no longer met criteria. There was one new case. The remaining five participants did not complete the assessment.

At 12 months postoperatively ($n=191$), none of the participants who met criteria at baseline met criteria for addictive-like eating. Five participants met criteria for addictive-like eating behavior at 12 months for the first time. The remaining six participants did not complete the assessment.

Association of Eating Behavior Variables with Weight Change Over Time

Table 3 presents the associations between baseline eating behavior or disorder variables and %WL at months 6 and 12. Controlling for age, gender, race, surgery type, and baseline BMI, participants who reported any SBEs at baseline experienced a 4.1 percentage point *greater* weight loss than those who did not have any SBEs ($p=0.028$). No other baseline eating behavior variables were significantly associated with weight loss.

Table 4 presents the associations between postoperative eating behavior or disorder variables and weight loss. In time-dependent eating behavior models, increases in disinhibition ($t(164)=-5.06$, $p<0.001$), hunger ($t(164)=-4.39$, $p<0.0001$), NEQ total ($t(164)=-2.71$, $p=0.008$), EDE-OBEs ($t(157)=-2.49$, $p=0.014$), EDE-BSV global ($t(158)=-3.35$, $p=0.001$) scores, and snacks per day

Table 3 Associations between baseline eating behavior or disorder variables and percent weight loss at postoperative months 6 and 12*

Variables	% Weight loss		
	β coefficient (95% CI)	*t* values	*p* values
Eating Disorder Examination–Bariatric Surgery Version			
Eating disorder diagnosis			
Lifetime, yes	− 1.1755 (− 3.6883, 1.3374)	− 0.92	0.3575
Current, yes	− 0.9217 (− 3.4976, 1.6542)	− 0.71	0.4814
Global score, per 1 point	0.6680 (− 0.3411, 1.6771)	1.30	0.1933
Picking/nibbling, per 1 point	− 0.0746 (− 0.2133, 0.0641)	− 1.06	0.2903
Average number of daily meals	0.6036 (− 0.8060, 2.0133)	0.84	0.3996
Average number of daily snacks	− 0.1699 (− 0.6653, 0.3255)	− 0.68	0.4998
Episodes of binge eating (past 28 days)			
Objective, any	− 0.7462 (− 3.1902, 1.6977)	− 0.60	0.5479
Subjective, any	4.0854 (0.4520, 7.7188)	2.22	0.0277
Objective, average	− 0.01671 (− 0.2129, 0.1795)	− 0.17	0.8669
Subjective, average	0.8331 (2.7068, 3.9446)	2.68	0.0080
Eating Inventory			
Disinhibition, per 1 point	− 0.1239 (− 0.3737, 0.1260)	− 0.98	0.3298
Cognitive restraint, per 1 point	− 0.1627 (− 0.3751, 0.0497)	− 1.51	0.1325
Hunger, per 1 point	0.0192 (− 0.2151, 0.2533)	0.16	0.2533
Night Eating Questionnaire			
Total score, per 1 point	− 0.0595 (− 0.1796, 0.0606)	− 0.98	0.3299
Yale Food Addiction Scale			
Symptom count, per 1 point	0.3539 (− 0.1824, 0.8903)	1.30	0.1948

*In all models, age, gender, race (White, Black, additional responses), surgery type (SG or RYGB), and baseline BMI were adjusted as covariates

CI, confidence interval

($t(157) = -2.69$, $p = 0.0079$) at 6 and 12 months were associated with *smaller* %WL. For every 5-unit increase on the measures at either 6 or 12 months, %WL was decreased for each of these eating variables: disinhibition, 2.97%; hunger, 2.83%; NEQ, 0.66%; OBEs, 2.84%; average snacks per day, 3.43%; and EDE Global, 5.88%, at the corresponding time point. No other eating behavior variables were significantly associated with %WL over 12 months.

Discussion

In this study of problematic eating behaviors among a diverse sample of participants, the majority of whom underwent SG, one preoperative variable and several postoperative variables were associated with %WL at the end of the first postoperative year. The presence of SBE at baseline predicted greater percent weight loss following surgery. This was in contrast to our hypothesis. As hypothesized self-reported disinhibition over eating, physical hunger, average number of daily snacks, globally elevated eating disordered attitudes and behaviors, presence of OBEs, and night eating symptoms *after surgery* were associated with lower %WL at 6 and 12 months. Other theoretically relevant variables assessed after surgery, such as addictive-like eating behaviors, picking, and nibbling behavior, as well as the frequency of meals, did not predict percent weight loss. Overall, the %WL with SG (23% at 6 months, 26% at 12 months) and RYGB (25% at 6 months, 30% at 12 months) were about comparable to previous studies, with Ahmed et al. reporting mean %WL of 24% and 29% at 6 and 12 months, respectively in patients who underwent SG, and losses of 26% and 34% at 6 and 12 months, respectively, in patients who underwent RYGB [24].

The presence of SBEs at baseline predicted greater postoperative %WL in the first year. While seemingly counterintuitive, SBEs may be attenuated by the physical properties of the operations. Patients at both bariatric programs in this study received extensive preoperative instruction by the program dietitians to diligently avoid overeating after surgery. Additionally, the negative physical effect of having an overeating episode after surgery could limit patients' engagement in the behavior. As reported from the LABS cohort, which largely consisted of RYGB procedures, participants with preoperative LOC over eating and who went into "remission" postoperatively lost more weight than those who never endorsed LOC over eating episodes [10]. This suggests that individuals who have some LOC eating prior to surgery may have more room

Table 4 Associations between postoperative eating behavior or disorder variables and percent weight loss at months 6 and 12*

Variables	% Weight loss		
	β coefficient (95% CI)	*t* values	*p* values
Eating Disorder Examination–Bariatric Surgery Version			
Eating disorder			
Current, yes	−3.4170 (−6.8587, 0.0247)	−1.96	0.0516
Global score, per 1 point	−1.4746 (−2.3436, −0.6056)	−3.35	0.0010
Picking/nibbling, per 1 point	−0.0123 (−0.0801, 0.0555)	−0.36	0.7213
Average number of daily meals	0.2272 (−0.9427, 1.3971)	0.38	0.7018
Average number of daily snacks	−0.6862 (−1.1901, −0.1823)	−2.69	0.0079
Episodes of binge eating (past 28 days)			
Objective, any	−1.3486 (−4.4700, 1.7728)	−1.02	0.3410
Subjective, any	0.6552 (−2.3618, 3.6722)	0.51	0.6234
Objective, average	−0.5677 (−1.0179, −0.1174)	−2.49	0.0138
Subjective, average	0.1455 (−0.9005, 1.1915)	0.27	0.7839
Eating Inventory			
Disinhibition, per 1 point	−0.5931 (−0.8244, −0.3618)	−5.06	<.0001
Cognitive restraint, per 1 point	−0.0440 (−0.1996, 0.1116)	−0.56	0.5777
Hunger, per 1 point	−0.5666 (−0.8215, −0.3116)	−4.39	<.0001
Night Eating Questionnaire			
Total score, per 1 point	−0.1318 (−0.2277, −0.0358)	−2.71	0.0074
Yale Food Addiction Scale			
Symptom count, per 1 point	−0.0035 (−0.4920, 0.4850)	−0.01	0.9888

*In all models, age, gender, race (White, Black, Other), surgery type (SG or RYGB), and baseline BMI were adjusted as covariates

CI, confidence interval

for improvement in their eating habits, which may contribute to greater weight loss.

Increased levels of disinhibition and hunger following bariatric surgery are associated with less sustained weight loss [8, 25]. This finding was replicated in the current study, suggesting that participants who respond with improvements in self-regulation regarding food and eating choices lose more weight in the first year. Further, in eight of eleven studies reviewed by Sheets and colleagues [3], a significant relationship was observed between lower %WL and any type of LOC eating, which was also replicated here. OBEs were endorsed by 11% at baseline, and just 2% of participants at 6 months and 4% at 12 months, with similar rates for SBEs, at 4%, 4%, and 2%, respectively. These ranges seem similar to estimates of LOC over eating episodes prior to surgery (11.5%), but lower than estimates following surgery (14.9%) reported by others [7]. However, their presence was still predictive of smaller weight loss.

Endorsement of global symptoms of disordered eating (e.g., eating concerns, shape concerns, weight concerns, and restraint) also was associated with smaller %WL at 12 months. Others have similarly found that global disordered eating attitudes and behaviors were associated with of lower total weight loss up to 2 years after surgery [26]. This suggests that maladaptive eating habits, as well as a constellation of attitudes towards one's body, can impact weight loss even in the first postoperative year.

Greater symptoms of night eating were also related to a smaller, early weight loss. Others have also found this association [13, 27]. An increasing number of studies show that eating in the later hours can negatively impact weight, produce lower levels of fat oxidation, and worsen glucose, insulin sensitivity, and cholesterol levels [28, 29]. It is also likely easier to consume this additional eating episode during the night in a fasted state than another time of the day given the restrictive nature of SG and RYGB. Thus, those who eat a large percent of their intake in the evening and nighttime may be at risk for smaller weight losses or weight regain due to both metabolic mechanisms and excess caloric intake.

Only 7% of the sample endorsed addictive-like eating behavior prior to surgery, and postoperative symptom counts, on average, were low. Symptom reports were lower than in previous studies, which range from 16 to 58% [15, 30, 31]. Endorsement of these symptoms declines after surgery, and the changes do not appear to be related to weight loss [15]. One possible reason for the lower endorsement of food addiction symptoms in the current sample could be higher inclusion of Black participants. Rates of eating disorders are believed to be low among Black and Hispanic-Americans, although it is unclear if these disorders are seen less frequently among persons of color or if they are not assessed and identified as regularly. However, at least one study has found no association between race and food addiction symptoms in a non-bariatric sample [32].

In general, participants ate a similar number of meals before and after surgery, but they decreased their snacking by about one episode per day. Several previous studies [7, 10, 33, 34] have linked picking and nibbling behaviors with smaller weight losses. We did not find this relationship between picking and nibbling, but we did observe a positive association between number of snacks per day with smaller weight loss.

Finally, we did not find differences in percent weight loss by gender or race. Previous longitudinal studies, such as the LABS study, have shown that identifying as White and as a woman was related to more favorable weight loss trajectories up to 7 years after surgery [2]. This could be related to several determinants, such as community composition, majority or minority status, sex, and age, as reviewed by Byrd and colleagues [35]. Given our sample was majority non-White in a city with a larger presence of Black than White residents, perhaps this conferred some benefit to our Black participants well-being, thus promoting similar weight loss with bariatric surgery.

Overall, endorsement of several problematic eating behaviors and experiences following surgery was associated with smaller percent weight losses at the end of the first postoperative year. The physical properties of bariatric surgery are likely strongest in the first 6 months after surgery; behavioral and psychosocial variables may have a greater impact over time [6, 36, 37].

Limitations of this study include attrition at the 6- and 12-month assessment points, a problem for many surgical outcome studies. While there was no difference at baseline for those who did not return for any postoperative assessments compared to those who did, it is unknown if persons who are doing well are less likely to return for visits, thinking that they are doing well and do not want to be bothered, or if persons who are struggling with disordered eating and weight gain are less likely to engage due to embarrassment or shame related to these behaviors. Additionally, although we performed structured interviews, used validated surveys, and performed assessments outside of clinical care to address possible impression management by participants, it is likely that participants still may have under-reported problematic eating symptoms. Further, the hormonal changes following SG and RYGB vary, which could also influence the eating behaviors we examined in this study. For example, we previously reported that in response to a mixed-nutrient meal, GLP-1 and PYY3–36 demonstrated an exaggerated post-prandial response that was significantly greater in RYGB than VSG at 6 months. However, this difference was attenuated and not significant at 18 months. Future studies that examine the interaction between hormonal and psychosocial variables would be helpful to tease out these possible relationships [38].

In sum, in this racially diverse sample of bariatric participants, several postoperative eating behaviors and experiences were associated with smaller percent weight losses in the first postoperative year. Only one eating behavior assessed prior to surgery (SBEs) predicted greater weight loss. The provision of more behavioral services for patients who experience problematic eating behaviors postoperatively could be beneficial in minimizing their impact on weight over time, although access to care and insurance coverage for those services would also be essential. The use of telemedicine may improve our reach for such interventions, but funding for such initiatives is needed to keep such postoperative interventions sustainable. Longer term follow-up of these participants, as weight loss plateaus for most individuals and weight regain occurs for some, will hopefully further elucidate these relationships.

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Declarations

Ethical Approval All procedures performed in 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.

Conflict of Interest Rebecca L. Ashare has an investigator-initiated grant from Novo Nordisk, Inc., for a study unrelated to current paper. Thomas A. Wadden reports serving on advisory boards for Novo Nordisk and WW International Co. and receiving grants from Novo Nordisk and Epitomee Medical Ltd. David B. Sarwer reports grants from FY2015 Pennsylvania Commonwealth Universal Research Enhancement Program Formula Funding (PA CURE); grants from National Institute of Dental and Craniofacial Research, during the conduct of the study; personal fees from Ethicon; and personal fees from Novo Nordisk, Inc., outside the submitted work. All other authors declare no competing interests.

References

1. Arterburn DE, Telem DA, Kushner RF, Courcoulas APl. Benefits and risks of bariatric surgery in adults: a review. JAMA. 2020;324(9):879–87.
2. Courcoulas AP, King WC, Belle SH, Berk P, Flum DR, Garcia L, et al. Seven-year weight trajectories and health outcomes in the longitudinal assessment of bariatric surgery (LABS) study. JAMA Surg. 2018;153(5):427–34. https://doi.org/10.1001/jamasurg.2017.5025.

3. Sheets CS, Peat CM, Berg KC, White EK, Bocchieri-Ricciardi L, Chen EY, et al. Post-operative psychosocial predictors of outcome in bariatric surgery. Obes Surg. 2015;25(2):330–45. https://doi.org/10.1007/s11695-014-1490-9.
4. Hindle A, de la Piedad GX, Brennan L. Early post-operative psychosocial and weight predictors of later outcome in bariatric surgery: a systematic literature review. Obes Rev. 2017;18(3):317–34. https://doi.org/10.1111/obr.12496.
5. Livhits M, Mercado C, Yermilov I, Parikh JA, Dutson E, Mehran A, et al. Preoperative predictors of weight loss following bariatric surgery: systematic review. Obes Surg. 2012;22(1):70–89. https://doi.org/10.1007/s11695-011-0472-4.
6. Sarwer DB, Allison KC, Wadden TA, Ashare R, Spitzer JC, McCuen-Wurst C, et al. Psychopathology, disordered eating, and impulsivity as predictors of outcomes of bariatric surgery. Surg Obes Relat Dis. 2019;15(4):650–5. https://doi.org/10.1016/j.soard.2019.01.029.
7. Conceição EM, Mitchell JE, Pinto-Bastos A, Arrojado F, Brandão I, Machado PPP. Stability of problematic eating behaviors and weight loss trajectories after bariatric surgery: a longitudinal observational study. Surg Obes Relat Dis. 2017;13(6):1063–70. https://doi.org/10.1016/j.soard.2016.12.006.
8. Konttinen H, Peltonen M, Sjöström L, Carlsson L, Karlsson J. Psychological aspects of eating behavior as predictors of 10-y weight changes after surgical and conventional treatment of severe obesity: results from the Swedish obese subjects intervention study. Am J Clin Nutr. 2015;101(1):16–24. https://doi.org/10.3945/ajcn.114.095182.
9. Martin-Fernandez KW, Martin-Fernandez J, Marek RJ, Ben-Porath YS, Heinberg LJ. Associations among psychopathology and eating disorder symptoms and behaviors in post-bariatric surgery patients. Eat Weight Disord. 2021;26(8):2545–53. https://doi.org/10.1007/s40519-021-01111-w.
10. Mitchell JE, Christian NJ, Flum DR, Pomp A, Pories WJ, Wolfe BM, et al. Postoperative behavioral variables and weight change 3 years after bariatric surgery. JAMA Surg. 2016;151(8):752–7. https://doi.org/10.1001/jamasurg.2016.0395.
11. Nasirzadeh Y, Kantarovich K, Wnuk S, Okrainec A, Cassin SE, Hawa R, et al. Binge eating, loss of control over eating, emotional eating, and night eating after bariatric surgery: results from the Toronto bari-PSYCH cohort study. Obes Surg. 2018;28(7):2032–9. https://doi.org/10.1007/s11695-018-3137-8.
12. Smith KE, Orcutt M, Steffen KJ, Crosby RD, Cao L, Garcia L, et al. Loss of control eating and binge eating in the 7 years following bariatric surgery. Obes Surg. 2019;29(6):1773–80. https://doi.org/10.1007/s11695-019-03791-x.
13. Ivezaj V, Lawson JL, Lydecker JA, Duffy AJ, Grilo CM. Examination of night eating and loss-of-control eating following bariatric surgery. Eat Weight Disord. 2022;27(1):207–13. https://doi.org/10.1007/s40519-021-01156-x.
14. Miller-Matero LR, Bryce K, Saulino CK, Dykhuis KE, Genaw J, Carlin AM. Problematic eating behaviors predict outcomes after bariatric surgery. Obes Surg. 2018;28(7):1910–5. https://doi.org/10.1007/s11695-018-3124-0.
15. Sevinçer GM, Konuk N, Bozkurt S, Coşkun H. Food addiction and the outcome of bariatric surgery at 1-year: prospective observational study. Psychiatry Res. 2016;30(244):159–64. https://doi.org/10.1016/j.psychres.2016.07.022.
16. Ambwani S, Boeka AG, Brown JD, Byrne TK, Budak AR, Sarwer DB, et al. Socially desirable responding by bariatric surgery candidates during psychological assessment. Surg Obes Relat Dis. 2013;9(2):300–5.
17. American Society for Metabolic and Bariatric Surgery. Estimate of bariatric surgery numbers, 2011–2019. https://asmbs.org/resources/estimate-of-bariatric-surgery-numbers, Website accessed May 5, 2022.
18. Sarwer DB, Wadden TA, Ashare RL, Spitzer JC, McCuen-Wurst C, LaGrotte C, et al. Psychopathology, disordered eating, and impulsivity in patients seeking bariatric surgery. Surg Obes Relat Dis. 2021;17(3):516–24. https://doi.org/10.1016/j.soard.2020.11.005.
19. First MB, Williams JBW, Karg RS, Spitzer RL. Structured Clinical Interview for DSM-5—Research Version (SCID-5 for DSM-5, Research Version; SCID-5-RV). Arlington, American Psychiatric Association; 2015
20. de Zwaan M, Swan-Kremeier L. Eating disorders examination: Bariatric surgery version. Available from the authors.
21. Stunkard AJ, Messick S. Eating inventory manual. San Antonio: Harcourt Brace Jovanovitch Inc; 1988.
22. Allison KC, Lundgren JD, O'Reardon JP, Martino NS, Sarwer DB, Wadden TA, et al. The night eating questionnaire (NEQ): psychometric properties of a measure of severity of the night eating syndrome. Eat Behav. 2008;9:62–72.
23. Gearhardt AN, Corbin WR, Brownell KD. Preliminary validation of the Yale food addiction scale. Appetite. 2009;52:430–6.
24. Ahmed B, King WC, Gourash W, Belle SH, Hinerman A, Pomp A, Dakin G, Courcoulas AP. Long-term weight change and health outcomes for sleeve gastrectomy (SG) and matched Roux-en-Y gastric bypass (RYGB) participants in the Longitudinal Assessment Of Bariatric Surgery (LABS) study. Surgery. 2018;164(4):774–83.
25. Nymo S, Børresen Skjølsvold O, Aukan M, Finlayson G, Græslie H, Mårvik R, Kulseng B, Sandvik J, Martins C. Suboptimal weight loss 13 years after Roux-en-Y gastric bypass: is hedonic hunger, eating behaviour and food reward to blame? Obes Surg. 2022. https://doi.org/10.1007/s11695-022-06075-z.
26. Pinto-Bastos A, de Lourdes M, Brandão I, Machado PPP, Conceição EM. Weight loss trajectories and psychobehavioral predictors of outcome of primary and reoperative bariatric surgery: a 2-year longitudinal study. Surg Obes Relat Dis. 2019;15(7):1104–12. https://doi.org/10.1016/j.soard.2019.04.018.
27. Colles SL, Dixon JB. Night eating syndrome: impact on bariatric surgery. Obes Surg. 2006;16(7):811–20. https://doi.org/10.1381/096089206777822160.
28. Allison KC, Hopkins CM, Ruggieri M, Spaeth AM, Ahima RS, Zhang Z, Taylor DM, Goel N. Impact of timing of eating on weight and metabolism. Curr Biol. 2021;31(3):650-657.e3. https://doi.org/10.1016/j.cub.2020.10.092.
29. Ravussin E, Beyl RA, Poggiogalle E, Hsia DS, Peterson CM. Early time-restricted feeding reduces appetite and increases fat oxidation but does not affect energy expenditure in humans. Obesity (Silver Spring). 2019;27(8):1244–54. https://doi.org/10.1002/oby.22518.
30. Brunault P, Ducluzeau P-H, Bourbao-Tournois C, Delbachian I, Couet C, Réveillère C, Ballon N. Food addiction in bariatric surgery candidates: prevalence and risk factors. Obes Surg. 2016;26(7):1650–3. https://doi.org/10.1007/s11695-016-2189-x.
31. Koball AM, Borgert AJ, Kallies KJ, Grothe K, Ames G, Gearhardt AN. Validation of the Yale food addiction scale 2.0 in patients seeking bariatric surgery. Obes Surg. 2021;31(4):1533–1540. https://doi.org/10.1007/s11695-020-05148-1.
32. Carr MM, Lawson JL, Wiedemann AA, Barnes RD. Examining impairment and distress from food addiction across demographic and weight groups. Eat Behav. 2021;43:101574. https://doi.org/10.1016/j.eatbeh.2021.101574.
33. Devlin MJ, King WC, Kalarchian MA, White GE, Marcus MD, Garcia L, Yanovski SZ, Mitchell JE. Eating pathology and experience and weight loss in a prospective study of bariatric surgery patients: 3-year follow-up. Int J Eat Disord. 2016;49(12):1058–67. https://doi.org/10.1002/eat.22578.
34. Devlin MJ, King WC, Kalarchian MA, Hinerman A, Marcus MD, Yanovski SZ, Mitchell JE. Eating pathology and associations

with long-term changes in weight and quality of life in the longitudinal assessment of bariatric surgery study. Int J Eat Disord. 2018;51(12):1322–30. https://doi.org/10.1002/eat.22979.
35. Byrd AS, Toth AT, Stanford FC. Racial disparities in obesity treatment. Curr Obes Rep. 2018;7(2):130–8. https://doi.org/10.1007/s13679-018-0301-3.
36. Chao AM, Wadden TA, Faulconbridge LF, Sarwer DB, Webb VL, Shaw JA, et al. Binge-eating disorder and the outcome of bariatric surgery in a prospective, observational study: Two year results. Obesity. 2016;24(11):2237–333. https://doi.org/10.1002/oby.21648.
37. Sarwer DB, Heinberg LJ. A review of the psychosocial aspects of clinically severe obesity and bariatric surgery. Am Psychol. 2020;75(2):252–64. https://doi.org/10.1037/amp0000550.
38. Alamuddin N, Vetter ML, Ahima RS, et al. Changes in fasting and prandial gut and adiposity hormones following vertical sleeve gastrectomy or Roux-en-Y-gastric bypass: an 18-month prospective study. Obes Surg. 2017;27:1563–72. https://doi.org/10.1007/s11695-016-2505-5.

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