Weight-loss maintenance in successful weight losers: surgical vs non-surgical methods

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Objective: As large weight losses are rarely achieved through any method except bariatric surgery, there have been no studies comparing individuals who initially lost large amounts of weight through bariatric surgery or non-surgical means. The National Weight Control Registry (NWCR) provides a resource for making such unique comparisons. This study compared the amount of weight regain, behaviors and psychological characteristics in NWCR participants who were equally successful in losing and maintaining large amounts of weight through either bariatric surgery or non-surgical methods.
Design: Surgical participants ($n=105$) were matched with two non-surgical participants ($n=210$) on gender, entry weight, maximum weight loss and weight-maintenance duration, and compared prospectively over 1 year.
Results: Participants in the surgical and non-surgical groups reported having lost approximately 56 kg and keeping $\geqslant 13.6$ kg off for 5.5 ± 7.1 years. Both groups gained small but significant amounts of weight from registry entry to 1 year ($P=0.034$), but did not significantly differ in magnitude of weight regain (1.8 ± 7.5 and 1.7 ± 7.0 kg for surgical and non-surgical groups, respectively; $P=0.369$). Surgical participants reported less physical activity, more fast food and fat consumption, less dietary restraint, and higher depression and stress at entry and 1 year. Higher levels of disinhibition at entry and increased disinhibition over 1 year were related to weight regain in both groups.
Conclusions: Despite marked behavioral differences between the groups, significant differences in weight regain were not observed. The findings suggest that weight-loss maintenance comparable with that after bariatric surgery can be accomplished through non-surgical methods with more intensive behavioral efforts. Increased susceptibility to cues that trigger overeating may increase risk of weight regain regardless of initial weight-loss method.

Keywords: weight maintenance; bariatric surgery; National Weight Control Registry; weight regain

Introduction

For approximately 1 in 20 individuals who are severely obese (body mass index (BMI) $\geqslant 40$ kg/m^2 or >100 lb overweight),[1] bariatric surgery is considered the most effective method for producing long-term weight loss.[2,3] On average, individuals who have bariatric surgery lose about 25% of their initial body weight within the first 12 months postoperatively.[4,5] Comparatively, individuals in behavioral weight-loss treatments typically lose 10% of their body weight.[6,7] However, in two recent studies using more intensive behavioral treatments in severely obese individuals, weight losses averaged 25% among treatment completers and 18% of participants lost 100 lb or more.[8,9]

Although surgical procedures more reliably produce large initial weight losses, it is not clear whether surgical patients are more successful at maintaining their weight losses than individuals who have lost comparable amounts of weight through non-surgical means. In the Swedish Obese Subjects intervention study, a large prospective investigation of the effects of weight loss in severely obese patients, surgically treated subjects regained nearly a third of the weight that they lost by 6-year follow-up.[5] In the two behavioral studies cited above, patients who achieved large initial weight losses of $\geqslant 100$ lb went on to regain between 35 and 38% of the weight they initially lost over the next 2 years and nearly 50% of this amount by 5 years.[8,9] To date, there has not been a direct comparison of weight-loss maintenance in individuals who have achieved significant weight loss through bariatric surgery or non-surgical approaches.

The National Weight Control Registry (NWCR), an ongoing longitudinal study of successful weight-loss maintainers, provides a unique resource for comparing individuals who have lost large amounts of weight through surgical or non-surgical means. Earlier, NWCR members who lost weight through bariatric surgery were compared with members who lost comparable amounts of weight through non-surgical methods, although these groups were not compared prospectively on weight-loss maintenance.[10]

The primary objective of this study was to evaluate whether NWCR participants who had lost and maintained comparable large amounts of weight through either bariatric surgery or non-surgical methods differed in weight regain over time. In addition, we compared the groups on weight-maintenance behaviors and psychological characteristics at registry entry and 1 year. Finally, we evaluated whether the contribution of behaviors and psychological characteristics to 1-year weight regain was a function of weight-loss method.

Methods

Participants

Participants were selected from the NWCR, a longitudinal study of individuals successful at long-term weight-loss maintenance. Participants had enrolled in the NWCR during the period of 1994–2006. Eligibility requirements for NWCR enrollment include having lost at least $\geqslant$13.6 kg, maintaining $\geqslant$13.6 kg for $\geqslant$1 year and being $\geqslant$18 years of age. This weight-loss inclusion criterion is used to capture persons of a wide range of weights who have lost at least 10% of their weight. A 10% weight loss is associated with substantial improvement in risk profiles for diabetes and cardiovascular disease.[11] The criterion for maintenance of weight loss for at least 1 year is consistent with Institute of Medicine criteria,[12] although it is recognized that the most successful individuals will have maintained their weight loss for longer than 1 year. Indeed, NWCR participants, on average, have maintained the minimum weight loss for nearly 6 years.[13]

To be included in this study, participants could not be pregnant and had to be enrolled in the NWCR for sufficient time to reach the 2-year assessment. From the remaining sample of 4902, 105 participants were identified as having undergone bariatric surgery. For each bariatric surgery participant, two registry members who achieved weight loss through non-surgical means were matched on sex, weight at registry entry, maximum weight loss within $\pm$15.9 kg and weight-maintenance duration at the time of study entry within $\pm$2 years. Surgical ($n=105$) and non-surgical participants ($n=210$) were then compared on weight-loss maintenance, weight-maintenance behaviors and psychological characteristics from registry entry to 1-year follow-up. Group differences in 2-year weight change were also examined, although this analysis was treated as exploratory, given limited sample size.

Of the 315 participants eligible for this study, 251 (80%) completed the 1-year assessment and 209 (66%) completed the 2-year assessment. Completion rates did not differ between the groups at 1 year (74% of surgical participants vs 82% of non-surgical participants; $P=0.10$) or at 2 years (69% of surgical participants vs 67% of non-surgical participants; $P=0.80$). Compared with non-completers at the 1-year assessment, completers were older (46.2 $\pm$ 10.9 vs 40.3 $\pm$ 9.7 years; $P=0.001$) and had maintained their weight loss for a longer duration (5.9 $\pm$ 7.8 vs 3.9 $\pm$ 3.4 years; $P=0.003$). Weight-maintenance duration was also different between completers and non-completers at the 2-year assessment (6.2 $\pm$ 8.1 vs 4.0 $\pm$ 3.9 years; $P=0.001$).

Procedures

Participants were recruited through local and national media coverage of the NWCR. Interested participants were provided the option of calling a 1–800 number or accessing the study website to receive enrollment information. Participants' self-reported current and past weight-related information was used to determine eligibility. Those who were found eligible were sent registry entry questionnaires (described below). All questionnaires were again completed at 1-year follow-up and an assessment for weight was sent to patients at 2-year follow-up. Registry participants did not receive compensation for their participation in the study.

Assessments

Demographic and weight history. At entry into the registry, participants provided demographic information (age, ethnicity, education level and marital status) and details of their weight history (maximum lifetime weight and current weight duration of the required minimum weight loss of 13.6 kg). Weight-history information was used to calculate BMI (kg/m^2). Weight-related information was also collected at the 1- and 2-year follow-up assessments. Although self-reported weight is prone to under-reporting, earlier and current self-reported weights have been shown to be valid measures of actual weight in a variety of populations, including bariatric surgery candidates.[14–16] Moreover, self-reported maximum ($r=0.98$, $P=0.001$) and entry weights ($r=0.97$, $P=0.001$) of NWCR participants have been validated earlier by physician's records.[17]

Weight-maintenance behaviors. Participants were asked about weight-loss maintenance strategies and related behaviors at baseline and 1-year follow-up. Estimates of daily caloric intake and percentage of calories derived from macronutrients (that is, fat, carbohydrates and protein) were obtained using the Block Food Frequency Questionnaire, a measure shown to correlate with 4-day food records.[18]

Additional questions assessed weekly consumption of breakfast and fast food meals.

The Paffenbarger Activity Questionnaire was used to provide estimates of total physical activity-related energy expenditure during the past 7 days as well as energy expended through various modes (that is, walking and stair climbing) and intensities (that is, light, medium and heavy) of physical activity.[19] The Paffenbarger Activity Questionnaire is demonstrated to be predictive of weight change in obese individuals as well as cardiovascular fitness level.[20,21]

Psychological factors. The Eating Inventory was used to assess eating factors including cognitive restraint (degree of conscious control overeating), disinhibition (susceptibility to loss of control overeating) and hunger (subjective feelings of hunger and food cravings).[22] Frequency of night eating was assessed on a 5-point scale (that is, 1 = never or less than once per month to 5 = every night). Participants' levels of depression and stress were also evaluated through the Centers for Epidemiologic Studies Depression Scale (CES-D) and the Perceived Stress Scale, respectively.[23,24]

Statistics

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS for Windows, Version 14.0; SPSS Inc., Chicago, IL, USA). Baseline demographic characteristics of surgical and non-surgical participants were compared using χ^2 analyses for categorical variables and independent *t*-tests for continuous variables. Analysis of covariance with repeated measures was used to examine group differences in changes in weight, adjusting for educational differences at entry to the study. We also conducted analyses in which missing weights due to non-completers were replaced by predicted values using various multiple imputation methods (SPSS for Windows, Version 14.0; SPSS Inc.). As findings were similar, only analyses of completers are presented here. Analysis of covariance with repeated measures was also used to assess changes in weight-maintenance behaviors and psychological characteristics for completers between the surgical and non-surgical groups between registry entry and 1-year follow-up, adjusting for educational differences at study entry. χ^2 analyses at entry and 1 year were used to assess differences in frequencies for categorical variables (night eating and physical activity) as a function of weight-loss method. Finally, regression analyses were conducted to evaluate predictors of weight regain. Behaviors and psychological characteristics identified as predictors of weight regain in past NWCR studies[13,17,25] were included in the model (that is, physical activity, % kcal from fat, dietary restraint, disinhibition and depressive symptoms). We used a five-step sequential procedure in which demographic and weight-related characteristics (that is, age, gender, education, maximum weight loss, weight-maintenance duration and weight at study entry) were entered in the first step, entry behaviors and psychological characteristics in step 2, 1-year changes in behaviors and psychological characteristics in step 3, interactions between group and entry variables in step 4, and interactions between group and change variables in step 5.

Statement of ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. This study was approved by The Miriam Hospital Institutional Review Board, Providence, RI, USA.

Results

Participant characteristics

Demographic and weight characteristics of the surgical and non-surgical groups at NWCR entry are presented in Table 1. No significant differences were observed between the groups, except that non-surgical participants were more highly educated. Similarly, despite attrition at 1- and 2-year follow-up, completers in the surgical and non-surgical groups differed on education level, but not on any of the matched parameters. Overall, at study entry, participants in both groups were predominantly Caucasian women. Both groups reported having been severely obese at their maximum lifetime weight (maximum BMI = 47.4 ± 8.9 kg/m^2, maximum weight = 135.4 ± 27.5 kg). Moreover, they reported having lost an average of 55.7 ± 20.2 kg and maintaining $\geqslant$13.6 kg for more than 5 years (5.5 ± 7.1 years). As reported earlier,[10] 58% of surgical participants reported having undergone Roux-en-Y gastric bypass surgery, 18% reported undergoing gastric banding and 24% did not specify the type of surgical procedure. The majority (68%) of non-surgical participants reported losing weight through formal assistance (for example, commercial weight program), whereas nearly a third (32%) reported losing weight without professional help.

Weight-loss maintenance in surgical and non-surgical participants

Surgical (n = 78) and non-surgical (n = 173) groups gained small amounts of weight from registry entry to 1 year (P = 0.034), but did not significantly differ in magnitude of weight regain (1.8 ± 7.5 and 1.7 ± 7.0 kg for surgical and non-surgical groups, respectively; P = 0.369) after adjusting for educational differences at study entry. Similar results were produced in the exploratory analysis examining weight regain in surgical (n = 72) and non-surgical participants (n = 137) who completed assessments at baseline, 1 year and 2 years. Findings showed that both groups gained weight from registry entry to 2-year follow-up (P = 0.001), although the groups did not significantly differ in magnitude of weight regain over this period (3.7 ± 11.9 and 5.2 ± 10.8 kg for surgical and non-surgical groups, respectively; P = 0.998).

Table 1 Demographic and weight characteristics at study entry by method of initial weight loss

	Surgical (n = *105*) *Mean (± s.d.)*	*Non-surgical* (n = *210*) *Mean (± s.d.)*	P-*value*
Age (year)	45.8 (10.3)	44.6 (11.2)	0.398[a]
Gender (%)			
Female	86	86	
Male	14	14	1.000[b]
Ethnicity (%)			
Caucasian	92.4	91.4	
African American	6.7	6.2	
Hispanic	0.0	2.4	
Others	1.0	0.0	0.209[b]
Education (%)			
<College degree	62.9	45.7	
⩾College degree	37.1	54.3	0.004[b]
Maximum weight (kg)	138.5 (28.3)	133.9 (27.1)	0.167[a]
Maximum BMI	48.6 (9.1)	46.9 (8.8)	0.111[a]
Entry weight (kg)	81.0 (17.1)	79.1 (17.1)	0.311[a]
Entry BMI	28.4 (5.6)	27.7 (5.1)	0.231[a]
Total weight loss (kg)	57.4 (20.2)	54.8 (20.1)	0.280[a]
Duration of weight loss (months)	65.6 (84.7)	65.5 (85.4)	0.993[a]

Abbreviation: BMI, body mass index. [a]Student's *t*-test (two-sided). [b]χ^2 test (two-sided). Note: Results based on χ^2 test. Standard errors of proportion are shown.

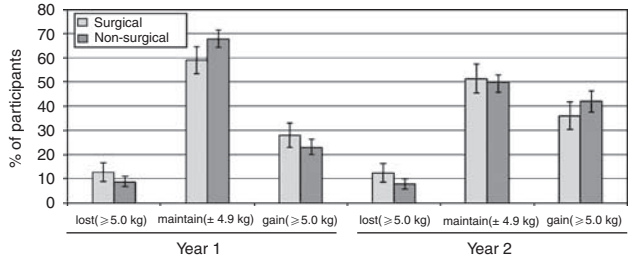

Figure 1 Distribution of levels of weight maintenance at 1- and 2-year follow-up assessments by method of initial weight loss. (Results based on χ^2 test. Standard errors of proportion are shown.)

As shown in Figure 1, the proportion of surgical and non-surgical participants who lost (⩾5 kg), maintained (± 4.9 kg) or gained (⩾5 kg) weight was similar at both 1 year ($\chi^2 = 1.98$, $P = 0.37$) and 2 years ($\chi^2 = 1.37$, $P = 0.51$). The majority of participants in both groups continued to maintain their weight loss within ± 4.9 kg.

Weight-maintenance behaviors and psychological characteristics

Weight-maintenance behaviors. Differences in dietary and physical activity behaviors between the surgical and non-surgical groups at both registry entry and 1-year follow-up are presented in Table 2. There were several significant differences between the surgical and non-surgical groups at both study entry and 1 year. Surgical participants reported consuming a greater proportion of calories from fat and a lesser proportion from carbohydrates than non-surgical participants. In addition, surgical participants reported consuming fast food more frequently and breakfast less frequently during the week compared with non-surgical participants. There were no significant group × time effects and the time effect was significant only for percentage of calories from fat and carbohydrates, with increases in percentage of fat calories and decreases in percentage of carbohydrate calories observed in both groups from study entry to 1-year follow-up.

Surgical participants reported expending fewer overall calories through physical activity and, specifically, calories expended in heavy-intensity activity. In a separate categorical analysis, total physical activity was split into two levels of caloric expenditure (0–2000 and >2000 kcal) based on American College of Sports Medicine exercise recommendations for weight loss and prevention of weight

Table 2 Weight-maintenance behaviors by method of initial weight loss: registry entry to 1-year follow-up

	Surgical mean (± s.d.)[a]	*Non-surgical mean (± s.d.)*[a]	P-*value*[b]		
			Group	*Time*	*Group × time*
Total daily intake (kcal)					
Entry	1356.7 (775.8)	1390.4 (581.2)			
1 year	1460.1 (706.5)	1407.3 (537.0)	0.857	0.365	0.292
% kcal from fat					
Entry	34.8 (12.4)	26.4 (12.0)			
1 year	37.0 (12.0)	27.6 (12.0)	0.001	0.001	0.521
% kcal from protein					
Entry	18.8 (3.9)	19.4 (4.2)			
1 year	18.4 (4.9)	19.1 (4.0)	0.106	0.539	0.783
% kcal from carbohydrate					
Entry	45.2 (12.0)	53.3 (14.0)			
1 year	44.1 (12.2)	52.7 (13.5)	0.001	0.026	0.858
Breakfast days per week					
Entry	5.8 (2.1)	6.5 (1.6)			
1 year	5.6 (2.3)	6.4 (1.6)	0.008	0.057	0.681
Fast food meals per week					
Entry	1.8 (2.6)	0.8 (1.8)			
1 year	2.0 (3.1)	0.9 (2.0)	0.002	0.948	0.469
Total activity (kcal per week)					
Entry	1865.2 (2196.5)	3006.3 (2773.5)			
1 year	1680.5 (2138.1)	3013.5 (3122.8)	0.001	0.546	0.349
Medium-intensity activity (kcal per week)					
Entry	481.7 (1021.7)	795.6 (1209.1)			
1 year	432.7 (923.4)	732.9 (1584.2)	0.056	0.896	0.898
Heavy-intensity activity (kcal per week)					
Entry	385.6 (863.4)	1137.4 (1886.9)			
1 year	414.3 (964.6)	1134.3 (2270.3)	0.002	0.778	0.935

[a]Actual (unadjusted values). [b]Analysis of covariance with repeated-measures F-test (two-tailed; *P*-value adjusted for differences in education).

regain in adults.[26] Results indicated that a smaller percentage of surgical participants as compared with non-surgical participants reported expending $\geqslant$2000 kcal per week of physical activity at both registry entry (33 vs 62%; $P=0.001$) and 1 year (31 vs 58%; $P=0.001$).

Psychological characteristics. Differences in psychological characteristics between surgical and non-surgical participants at both registry entry and 1-year follow-up are presented in Table 3. Higher levels of depression and stress were reported in the surgical group, and both groups reported significant ($P<0.01$) increases in the intensity of depressive symptoms over 1 year. Mean depressive symptoms scores at 1 year exceeded the threshold for clinical significance in the surgical group (that is, CES-D$\geqslant$16), and separate categorical analyses revealed a borderline significant difference in the proportion of subjects in the surgical (44%) and non-surgical (30%) groups who scored at or above this cutoff at 1 year ($P=0.051$).

At both time points, surgical participants also reported lower dietary restraint than non-surgical participants. In addition, separate categorical analyses revealed that a greater percentage of surgical participants reported night eating at least one time per week as compared with non-surgical participants at both registry entry (14 vs 5%; $P=0.012$) and 1-year follow-up (16 vs 4%; $P=0.004$).

Predictors of weight regain in surgical and non-surgical participants

In the final multivariate regression model, results indicated that the linear combination of variables was significantly related to 1-year weight regain, $R^2=0.278$, F (26, 131) = 1.93, $P=0.008$. Surgical and non-surgical participants who had higher levels of disinhibition at entry to the study ($\beta=0.37$; $t=3.62$; $P=0.001$) and greater increases in disinhibition ($\beta=0.36$; $t=3.48$; $P=0.001$) regained the most weight over 1 year. No other predictors were significant in the final model and there were no interactions with initial weight-loss method.

Table 3 Psychological characteristics by method of initial weight loss: registry entry to 1-year follow-up

	Surgery mean (± s.d.)[a]	*Non-surgical mean (± s.d.)*[a]	P-*value*[b]		
			Group	*Time*	*Group × time*
Depression					
Entry	12.3 (12.2)	9.2 (8.5)			
1 year	17.2 (14.8)	11.9 (10.2)	0.015	0.001	0.230
Stress					
Entry	6.6 (3.6)	4.9 (2.6)			
1 year	6.4 (4.0)	5.2 (3.0)	0.015	0.879	0.234
Dietary restraint					
Entry	12.8 (4.7)	15.4 (3.3)			
1 year	12.7 (5.0)	15.4 (3.1)	0.001	0.692	0.622
Disinhibition					
Entry	7.8 (4.0)	7.4 (3.6)			
1 year	7.7 (4.0)	7.7 (3.9)	0.679	0.613	0.215
Hunger					
Entry	5.5 (3.2)	4.5 (3.2)			
1 year	5.6 (3.7)	4.8 (3.3)	0.066	0.095	0.473

[a]Actual (unadjusted values). [b]Analysis of covariance with repeated-measures F-test (two-tailed; *P*-value adjusted for differences in education).

Discussion

Although achievement of large initial weight losses occurs more frequently and rapidly through bariatric surgery than through non-surgical or behavioral approaches, it is not known whether those who do succeed through behavioral approaches are more or less successful at long-term maintenance of their weight loss. The NWCR provides a unique opportunity to make this comparison. Using the NWCR, we were able to identify matched groups of surgical and non-surgical patients who had on an average lost 56 kg or over 40% (41%) of their maximum body weight, had changed from severely obese (BMI = 47.4 kg/m^2) to overweight (BMI = 27.9 kg/m^2) and had maintained the large weight losses for an average of 5.5 years at entry into the study.

There were no significant differences in the amount of weight regain between surgical and non-surgical participants. For both groups, weight regain averaged about 2 kg per year. Moreover, the majority of surgical and non-surgical participants remained within ± 4.9 kg of their baseline weight at years 1 and 2. These findings suggest that individuals who have lost and maintained large amounts of weight through non-surgical approaches may be equally successful at maintaining their weight losses as individuals who have lost comparable amounts of weight through surgical approaches.

Similar to our earlier study,[10] surgical and non-surgical participants were clearly differentiated by the behaviors they used to maintain their weight loss at entry into the study, and this study showed that these differences persisted over time. These behavioral differences suggest that the participants who achieved large weight losses through non-surgical methods had to work harder to maintain their weight losses than the surgical participants. Findings indicated that although both groups reported a similar caloric intake, non-surgical participants reported more conscious control over their eating and a lower percentage of calories from fat at both time points. Surgical participants reported consuming a high-fat diet ($\geqslant$35% of kcal from fat), whereas non-surgical participants consumed a low-fat diet (<28% of kcal from fat).[27] Similarly, surgical participants reported more frequent consumption of fast food meals. The surgical group's higher fat diet may have been a function of time since surgery. With increasing duration of the postoperative period and stretching of the gastric pouch and stoma, not only could higher fat foods be better digested but also greater

amounts could be consumed, thereby promoting a greater fat intake.[28] Surgical participants also derived a lesser percentage of calories from carbohydrates, possibly owing to learned dumping-related aversions to high-sugar foods, modified taste perceptions and/or macronutrient balance such that as fat calories increased, carbohydrate calories decreased.[29–31]

Whether the non-surgical participants' lower fat/higher carbohydrate diet is healthier or provides additional weight-control benefits compared with the surgical participants' higher fat/lower carbohydrate diet is uncertain. In a recent randomized controlled trial involving obese patients, Shai *et al*.[32] showed that a low-fat, restricted calorie diet produced significantly less weight loss and lesser reduction in total cholesterol to high-density lipoprotein ratio over 2 years compared with a low-carbohydrate, non-restricted calorie diet. By contrast, other researches have shown no significant differences in long-term weight control in participants consuming a low-fat vs low-carbohydrate diet.[31,33] The effect of different diets on long-term weight loss and disease risk profiles in individuals who have lost large amounts of weight through surgical and non-surgical approaches requires further investigation.

Consistent with the earlier studies of successful weight maintainers, both groups reported engaging in high levels of physical activity.[17,34] Non-surgical participants, similar to our earlier study,[10] reported expending significantly more calories through physical activity than surgical participants. In addition, only one-third of the surgical group reported engaging in a level of physical activity consistent with recommendations for prevention of weight regain compared with 60% of the non-surgical group.[26] Although surgical participants achieved similar weight maintenance with less physical activity, the long-term consequences of these lower and declining levels of physical activity over time are unknown. Longitudinal research demonstrates that rate of recovery from comorbidities after bariatric surgery decelerates along with weight regain.[4] Given the importance of physical activity for non-surgical weight control and health-related outcomes independent of body weight, the role of physical activity in promoting maintenance of weight loss and improvements in comorbidities following bariatric surgery merits investigation in treatment-controlled trials.[35,36]

Despite both groups reporting high levels of activity-related energy expenditure and low calorie intake, weight regain still occurred. One explanation for this finding may be measurement error associated with the use of self-report instruments; participants may have overestimated their physical activity and underestimated their caloric intake.[37,38] The occurrence of weight regain may also be attributed to homeostatic processes that oppose long-term weight loss in postobese individuals.[39–42]

Examination of psychological characteristics in the surgical and non-surgical participants revealed that both groups reported an increase in depressive symptoms from study entry to 1-year follow-up. However, whether these increased levels of depressive symptoms still remain significantly below pre-weight loss levels cannot be determined as depressive symptoms were assessed only after weight loss. Earlier studies involving assessment of depression before and after successful surgical and non-surgical weight-loss treatments indicate improvements, not worsening, in depression.[7,43–46]

Interestingly, surgical participants were found to report higher levels of depression than non-surgical participants at both study entry and follow-up. This finding should be interpreted with caution because participants were not randomized to surgery and non-surgical groups and, as noted above, pre-weight loss levels of depressive symptoms are unknown. Nonetheless, it is still concerning that 44% of surgical participants reported depressive symptoms that surpassed the minimal threshold for clinical significance, particularly in light of recent findings indicating a higher risk of suicide death in bariatric surgery patients.[47,48] Given the estimated 25–30% of patients who report symptoms indicative of clinical depression at the time of evaluation for bariatric surgery,[49] further study and monitoring of the course of depressive symptoms and related factors including stress across longer postoperative periods are needed.

We also evaluated the importance of behaviors and psychological characteristics at study entry and across 1 year in relation to weight regain within both groups. Interestingly, our findings showed that the initial method of weight loss did not moderate associations between behaviors or psychological characteristics and weight regain. Higher levels of disinhibition at study entry and increases in disinhibition over 1 year emerged as the only significant predictors of weight regain in surgical and non-surgical participants. These findings are consistent with other studies showing that increased susceptibility to cues that trigger impulsive eating undermines weight loss and long-term weight-loss maintenance.[17,50] Recent research also shows that grazing and loss of control overeating in bariatric surgery patients are related to poorer weight-loss outcomes.[51] Our findings that disinhibition is associated with weight regain beyond the active weight-loss period suggest that modifying disinhibited eating patterns might improve weight-loss maintenance following bariatric surgery.

This study has several limitations. Participants in this study were derived from the NWCR, a self-selected sample of successful weight-loss maintainers who may be more determined in their weight-loss efforts than the general population of successful weight-loss maintainers, and are certainly different from the general population of obese persons. The gender and ethnic composition of participants in this study, while being less diverse than those of the general population of overweight individuals, resemble national trends in individuals who undergo bariatric surgery.[52,53] Further, the surgical group may have achieved the significant weight losses more easily and at a faster rate than those who achieved these weight losses non-surgically.

Although not representative of the population at large, these NWCR participants provided an opportunity to compare those who were successful at maintaining large weight losses through bariatric surgery or non-surgical methods and to see if they differed in long-term maintenance and associated behaviors and psychological characteristics over time.

Another limitation is the use of self-report data. In an earlier NWCR study, participants' self-reported weights were shown to correlate strongly with those from physician records.[17] Nevertheless, self-reporting of weight and weight-related behaviors is still subject to issues of under-reporting/over-reporting and social desirability.[37,38] Our sample size may also have limited the ability to detect small effects. Finally, although we controlled for group differences in education at study entry, education does not necessarily encompass all socioeconomic status-related factors such as type of employment, location of residence/neighborhood and income level that could affect both performance of various weight-control behaviors and access to related literature and information. The strengths of this study include the prospective design, matching of surgical and non-surgical participants on demographic and multiple weight characteristics, and assessment of a wide range of weight-related behaviors and psychological characteristics.

In summary, this study suggests that weight loss and maintenance comparable to those observed after bariatric surgery can be accomplished through behavioral methods alone, although this may involve more intensive efforts over a longer duration. Future research should focus on ways to increase and maintain physical activity and better monitor psychological parameters in bariatric surgery patients to facilitate optimal long-term weight control. In addition, designing methods to increase resistance to cues that trigger overeating among individuals who have achieved large weight losses through bariatric or non-surgical methods may assist in preventing weight regain.

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