

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^{1–4}

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ABSTRACT

Background: There is a need for a better understanding of the factors that influence long-term weight outcomes after bariatric surgery.

Objective: We examined whether pretreatment and posttreatment levels of cognitive restraint, disinhibition, and hunger and 1-y changes in these eating behaviors predict short- and long-term weight changes after surgical and conventional treatments of severe obesity.

Design: Participants were from an ongoing, matched (nonrandomized) prospective intervention trial of the Swedish Obese Subjects (SOS) study. The current analyses included 2010 obese subjects who underwent bariatric surgery and 1916 contemporaneously matched obese controls who received conventional treatment. Physical measurements (e.g., weight and height) and questionnaires (e.g., Three-Factor Eating Questionnaire) were completed before the intervention and 0.5, 1, 2, 3, 4, 6, 8, and 10 y after the start of the treatment. Structural equation modeling was used as the main analytic strategy.

Results: The surgery group lost more weight and reported greater decreases in disinhibition and hunger at 1- and 10-y follow-ups (all $P < 0.001$ in both sexes) than the control group did. Pretreatment eating behaviors were unrelated to subsequent weight changes in surgically treated patients. However, patients who had lower levels of 6-mo and 1-y disinhibition and hunger ($\beta = 0.13$ – 0.29 , $P < 0.01$ in men; $\beta = 0.11$ – 0.28 , $P < 0.001$ in women) and experienced larger 1-y decreases in these behaviors ($\beta = 0.31$ – 0.48 , $P < 0.001$ in men; $\beta = 0.24$ – 0.51 , $P < 0.001$ in women) lost more weight 2, 6, and 10 y after surgery. In control patients, larger 1-y increases in cognitive restraint predicted a greater 2-y weight loss in both sexes.

Conclusion: A higher tendency to eat in response to various internal and external cues shortly after surgery predicted less-successful short- and long-term weight outcomes, making postoperative susceptibility for uncontrolled eating an important indicator of targeted interventions. This trial was registered at clinicaltrials.gov as NCT01479452. *Am J Clin Nutr* 2015;101:16–24.

Keywords bariatric surgery, eating behavior, obesity treatment, Three-Factor Eating Questionnaire, weight loss

INTRODUCTION

The current food-rich and sedentary environment has resulted in the markedly increased prevalence of obesity [BMI (in kg/m^2) ≥ 30] and extreme obesity (BMI ≥ 40) during the past decades

(1, 2). Long-term weight loss in this environment has proven to be extremely difficult; a large part of the weight lost during a lifestyle intervention is often regained in the following years (3). Bariatric surgery yields a significant and sustained weight reduction for the majority of severely obese individuals with accompanied improvements in health status (4–6) and health-related quality of life (7). Nonetheless, bariatric surgery is also associated with risks and postoperative complications, and slow weight regain after reaching maximal weight loss is frequent in patients (6, 8). Despite considerable research efforts, factors influencing long-term postsurgical outcomes are not well understood (9, 10). Eating behavior and its determinants are one important area of investigation because long-term outcomes may largely depend on the ability of the patient to incorporate and maintain changes in eating behaviors induced by the surgery.

One of the most-frequently used instrument to assess psychological aspects of eating behaviors is the Three-Factor Eating Questionnaire (TFEQ)⁵ (11), which taps the cognitive restraint

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³ Supplemental Figure 1 is available from the Supplemental data" link in the online posting of the article and from the same link in the online table of contents at <http://ajcn.nutrition.org>.

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⁵ Abbreviations used: CFI, comparative fit index; FIML, full information maximum likelihood; GBP, gastric bypass; LGM, latent growth modeling; RMSEA, root mean squared error of approximation; SOS, Swedish Obese Subjects; SRMR, standardized root mean square residual; TFEQ, Three-Factor Eating Questionnaire; VBG, vertical banded gastroplasty.

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of eating (tendency to restrict food intake to lose weight or prevent weight gain), disinhibition (tendency to eat in response to a variety of food and eating stimuli), and susceptibility to hunger (subjective feelings of hunger and food cravings). Postoperative improvements in these and related aspects of eating behavior (including binge-eating status) have been consistently observed in bariatric surgery patients, but research that documented long-term changes has been scarce (12). Furthermore, the evidence regarding the influence of eating behaviors on postsurgical weight outcomes has been mixed (9, 13). A few small-scale studies that predominantly used the TFEQ reported no associations between preoperative eating behaviors and the extent of weight loss ~ 1 y after the operation (14–16), whereas in other studies, higher baseline cognitive restraint and lower baseline susceptibility for overeating emerged as significant predictors of a greater 1- or 2-y weight loss (17–19). Nonetheless, scattered evidence has suggested that eating behaviors observed shortly after surgery could play a more significant role in later weight outcomes than do presurgical eating behaviors (13).

Most previous studies have been based on relatively small samples of participants with rather short follow-up periods (extending only 1 or 2 y after surgery), and these methodologic limitations may partly explain the difficulties in finding factors that consistently predict weight outcomes across studies. In the current study, the first aim was to investigate 10-y changes in cognitive restraint, disinhibition, and hunger in 2010 surgically treated and 1916 conventionally treated severely obese patients. Furthermore, the main objective was to examine whether pre-treatment and posttreatment levels of eating behaviors and 1-y changes in these behaviors predicted 2-, 6-, and 10-y weight outcomes.

SUBJECTS AND METHODS

Study sample and design

Participants were from an ongoing, matched (nonrandomized), prospective intervention trial of the Swedish Obese Subjects (SOS) study. The SOS study is a nationwide project comprising a cross-sectional matching study of obese persons, an intervention trial of the health effects of intentional weight reduction, and a population study. All regional ethical review boards in Sweden approved the study protocol, and all patients gave informed consent to participate.

Between September first 1987 and 31 January 2001, the SOS intervention study enrolled 4047 severely obese subjects at 25 surgical departments and 480 primary healthcare centers (6, 20, 21). Patients were recruited from a matching examination, which was completed by 6905 patients, 5335 of whom were eligible for inclusion in the study. The inclusion criteria were age 37–60 y and BMI ≥ 34 for men and BMI ≥ 38 for women at recruitment. Exclusion criteria were earlier surgery for a gastric or duodenal ulcer, earlier bariatric surgery, a gastric ulcer or myocardial infarction during the past 6 mo, ongoing malignancy, active malignancy during the past 5 y, a bulimic eating pattern, drug or alcohol abuse, psychiatric or cooperative problems that contraindicated bariatric surgery, and other contraindicating conditions (e.g., chronic glucocorticoid or anti-inflammatory treatment). In the SOS intervention study, 2010 individuals who elected surgery (a joint decision by the patient and the medical doctor)

constituted the surgery group, and a contemporaneously matched control group of 2037 individuals was created by using 18 matching variables (sex, age, weight, height, waist circumference, hip circumference, systolic blood pressure, s-cholesterol, s-triglycerides, smoking, diabetes, premenopausal/postmenopausal status, 4 psychosocial variables associated with mortality, and 2 personality traits related to treatment preferences). Although a surgical patient and his or her conventionally treated control subject always started the study on the day of surgery, the matching was not performed at an individual level. Instead, the matching algorithm selected controls in a way that current mean values of matching variables in the control group became as similar as possible to current mean values in the surgery group according to the method of sequential treatment assignment (22). As reported previously (4–6), the matching procedure unexpectedly created a control group that was slightly lighter in weight and older than the surgery group. However, these differences were likely to have had little impact in the current study that investigated predictors of individual weight changes separately in the 2 treatment groups.

In the surgery group, 376 subjects underwent nonadjustable or adjustable banding, 1369 subjects underwent vertical banded gastroplasty (VBG), and 265 subjects underwent gastric bypass (GBP) as determined by the surgeon. All surgical patients were given instructions on nutrition. Subjects in the control group were offered conventional treatment at their regular primary healthcare center. The treatment was not standardized, and the treatment regimen varied according to local practices from a sophisticated lifestyle intervention and behavior modification to a lack of specific treatment. All patients underwent a health examination and completed various questionnaires before the intervention. The 2 treatment groups were followed in the same manner, and follow-up was carried out through out-patient visits and mail-out and mail-back questionnaires at 0.5, 1, 2, 3, 4, 6, 8, 10, 15, and 20 y after the start of treatment.

The current analyses were restricted to 10 y after the start of the study because a considerable proportion of subjects had not yet reached the time for their 15- or 20-y examination (21). Of 2037 subjects referred to the control group, 121 subjects underwent bariatric surgery during the 10-y follow-up period and were excluded from the current analyses, which resulted in 1916 conventionally treated cases. At 2-, 6-, and 10-y follow-ups, information on weight was available for 91.9% ($n = 1848$), 76.4% ($n = 1535$), and 73.2% ($n = 1471$) of 2010 surgically treated subjects and 81.6% ($n = 1563$), 66.8% ($n = 1280$), and 61.9% ($n = 1186$) of 1916 conventionally treated subjects.

Measures

Body weight was measured in light clothing without shoes to the nearest 0.1 kg by using calibrated balances or electronic scales. Height was measured in a standing position without shoes to the nearest 0.01 m. The percentage of weight change from pretreatment weight was the main outcome variable of interest.

The 51-item TFEQ (11) was used to assess eating behaviors. The instrument contained 36 items with a yes or no response format, 14 items on a 4-point response scale, and a vertical rating scale from 0 to 10. All item responses were dichotomized and summed up into 3 scales as follows: cognitive restraint of eating (21 items; scale range: 0–21), disinhibition (16 items; scale

range: 0–16), and susceptibility to hunger (14 items; scale range: 0–14). Higher scores represented more cognitive restraint, disinhibition, and hunger. The Swedish version was translated according to standard procedures for the cross-cultural adaption of questionnaires (23).

Statistical analyses

All analyses were conducted separately in surgically and conventionally treated men and women. First, we calculated average levels and changes in weight and eating behaviors over the 10-y study period. Differences between surgical and conventional patients were tested by using an ANOVA or ANCOVA (baseline level was adjusted in the analysis of longitudinal treatment effects). We also used an ANOVA or ANCOVA to test whether eating behavior mean scores differed between surgically treated patients with more- and less-successful 10-y weight change outcomes (weight gain or weight loss <10.0%, weight loss from 10.0% to 19.9%, and weight loss \geq 20.0%). Only subjects with no missing data were included in each of these descriptive analyses.

Second, a structural equation modeling was used to analyze effects of eating behaviors on changes in weight during the 10-y follow-up period. Models were estimated separately for pretreatment and posttreatment (6-mo and 1-y) eating behaviors as well as for 2-, 6-, and 10-y percentages of weight change from pretreatment weight. Cognitive restraint, disinhibition or hunger, pretreatment age, pretreatment weight, and surgery type [non-adjustable and adjustable bandings (reference category), VBG, or GBP] served as independent variables in these models that predicted weight changes. Disinhibition and hunger were analyzed in separate models because of their high intercorrelations ($r \sim 0.70$) in both treatment groups (results concerning cognitive restraint were reported from models that contained disinhibition). These structural equation modeling analyses were equivalent to multiple linear regressions because each model had only one dependent variable and did not contain any latent variables.

Third, latent growth modeling (LGM) (24), which is part of the structural equation modeling framework, was used to model individual differences in 1-y changes in cognitive restraint, disinhibition, and hunger. In the LGM, change trajectories were specified by means of the following 2 latent variables: intercept (the initial level of the variable) and slope (the rate of change over time) factors. As a part of the LGM parameterization, loadings of pretreatment, 6-mo, and 1-y measurements of eating behaviors on the intercept factor were all fixed to equal one (Figure 1). The first 2 time loadings on the slope factor were fixed at 0 and 0.5, whereas the last time score was estimated as a free variable (instead of being fixed to one) to take into account the non-linearity of change in eating behaviors. The LGM of each eating behavior was initially estimated separately [all models fitted data adequately: chi-square test = 1.07–4.87 (all $P > 0.05$) in the surgical group and 1.53–5.54 (all $P > 0.05$) in the conventional group], but the main interest was to analyze whether 1-y changes (slope) in cognitive restraint and disinhibition and hunger predicted 2-, 6-, and 10-y weight outcomes as displayed in Figure 1. Several types of fit indexes were used to evaluate the overall model fit, including the chi-square statistic, standardized root mean square residual (SRMR), comparative fit index (CFI), and root mean squared error of approximation (RMSEA). As proposed by Hu and Bentler (25), CFI values ≥ 0.95 , SRMR values

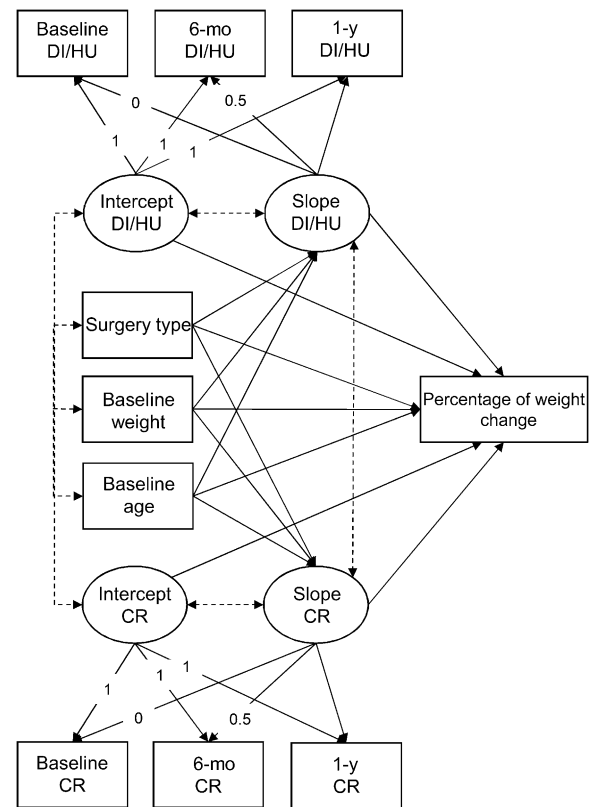


FIGURE 1 The latent growth model used to estimate effects of 1-y changes in CR and DI/HU on 2-, 6-, and 10-y percentage of weight change from baseline weight in surgically and conventionally treated patients. Baseline age, baseline weight, and surgery type [nonadjustable and adjustable bandings (reference category), vertical banded gastroplasty, or gastric bypass] were included as covariates in models. Disinhibition and hunger were analyzed in separate models (results concerning cognitive restraint were reported from models that contained disinhibition). Solid arrows represent regression effects, whereas dashed double arrows signify correlations. CR, cognitive restraint; DI/HU, disinhibition or hunger.

≤ 0.08 , and RMSEA values ≤ 0.06 were considered to indicate a good fit for data.

Full information maximum likelihood (FIML) was used as an estimation method for the structural equation models. FIML allows for the estimation with missing data and produces less-biased and more reliable results than do conventional techniques for handling missing data, such as list-wise deletion or unconditional and conditional mean imputations (26, 27). All structural equation modeling analyses were performed with Mplus statistical software (version 7; Muthen & Muthen), whereas IBM SPSS Statistics 21 software (IBM Corp.) was used for the other analyses.

RESULTS

Ten-year changes in weight

Weight characteristics before treatment and 2, 6, and 10 y after the start of the study are shown in Table 1. In surgically treated patients, the average maximum weight loss occurred at 1 y follow-up whereby men lost 23.7% and women 25.4% of their baseline weight (not shown in Table 1). The mean weight reduction at 10 y follow-up was 15.5% for men and 17.8% for women. Ten years after surgery, 69.6% of men and 74.1% of



TABLE 1Body weight characteristics before treatment and after 2, 6, and 10 y in surgically and conventionally treated patients¹

	Men		Women	
	Surgical	Conventional	Surgical	Conventional
Pretreatment age, y	47.2 ± 5.8 ²	48.7 ± 6.1*	47.2 ± 6.0	49.0 ± 6.3*
Weight, kg				
Pretreatment	132.7 ± 16.9	124.1 ± 16.2*	116.1 ± 13.8	110.4 ± 14.7*
2-y follow-up	102.7 ± 16.1	124.2 ± 17.0*	87.8 ± 14.6	109.8 ± 14.9*
6-y follow-up	109.2 ± 17.5	125.1 ± 18.0*	94.0 ± 16.0	111.1 ± 15.9*
10-y follow-up	111.3 ± 18.9	126.2 ± 19.6*	94.4 ± 16.3	111.1 ± 17.5*
BMI, kg/m ²				
Pretreatment	41.3 ± 4.8	38.5 ± 4.6*	42.8 ± 4.3	40.7 ± 4.6*
2-y follow-up	32.0 ± 4.6	38.4 ± 4.9*	32.4 ± 5.0	40.4 ± 4.7*
6-y follow-up	34.0 ± 4.9	39.0 ± 5.2*	34.9 ± 5.5	41.2 ± 5.1*
10-y follow-up	34.8 ± 5.5	39.3 ± 5.6*	35.1 ± 5.7	41.3 ± 5.7*
Percentage of weight change				
2-y change	-22.2 ± 10.2	0.0 ± 7.1*	-23.9 ± 10.7	-0.0 ± 7.6*
6-y change	-17.0 ± 10.6	1.6 ± 9.9*	-18.3 ± 11.7	1.6 ± 9.7*
10-y change	-15.5 ± 11.4	2.9 ± 12.3*	-17.8 ± 12.3	1.7 ± 11.4*
10-y weight-change outcome, % (n)				
Weight loss ≥0.0%	33.7 (144)	1.9 (7)**	41.3 (431)	2.5 (21)**
Weight loss 10.0–19.9%	35.8 (153)	8.6 (31)	32.9 (343)	10.8 (89)
Weight loss <10.0% or weight gain	30.4 (130)	89.4 (322)	25.9 (270)	86.7 (716)

¹*n* = 427–590 for men and *n* = 1044–1420 for women in the surgical group, *n* = 360–564 for men and *n* = 826–1352 for women in the conventional group. *Significant difference between surgical and conventional patients, *P* < 0.001 (ANOVA/ANCOVA). Baseline level was adjusted in the analysis of longitudinal treatment effects. **Significant difference in 10-y weight change outcome between surgical and conventional patients, *P* < 0.001 (chi-square test).

²Mean ± SD (all such values).

women had lost ≥10% of their baseline weight, whereas 9.6% of men and 7.0% of women (not shown in Table 1) had gained weight from baseline. In conventionally treated patients, the average maximum weight loss was observed at 6 mo follow-up and was 0.9% for both sexes (not shown in Table 1), whereas a weight gain of 2.9% for men and 1.7% for women occurred 10 y after the start of the study. At 10 y follow-up, 10.6% of men and 13.3% of women had succeeded to lose ≥10% of their baseline weight, whereas 53.4% of men and 55.2% of women (not shown in Table 1) had gained weight.

Ten-year changes in eating behaviors

Surgically treated patients reported large 1-y increases in cognitive restraint (88% in men and 47% in women) and large 1-y decreases in disinhibition (54% and 53%, respectively) and hunger (62% and 58%, respectively) on the basis of calculated estimates for effect size (Table 2). Relative to baseline, 10-y reductions in disinhibition and hunger remained large in size, whereas 10-y increases in restraint were small to moderate in magnitude. In conventionally treated patients, small 1-y increases in cognitive restraint (18% in men and 13% in women) and small 1-y decreases in disinhibition (10% in both sexes) and hunger (20% in men and 14% in women) were observed (Table 2). Disinhibition and hunger scores tended to further decrease during the latter part of the follow-up period resulting in moderate reductions at 10 y follow-up compared with baseline, whereas increases in restraint scores were comparable between 1- and 10-y follow-up assessments. See **Supplemental Figure 1** for 10-y trends in average eating behaviors in the 3 surgery-type groups. Banding patients experienced smaller 6-mo and 1-y decreases in disinhibition and hunger than

GBP and VBG patients did, and these differences tended to remain for the rest of the study period. Moreover, banding and VBG were related to higher postoperative cognitive restraint scores than GBP.

Eating behavior mean scores over the study period for surgically treated patients with more and less successful 10-y weight change outcomes are shown separately in **Figure 2**. For conventionally treated patients, overall mean values are shown. In the surgery group, pretreatment disinhibition (*P* = 0.733 in men and *P* = 0.830 in women) and hunger (*P* = 0.099 in men and *P* = 0.309 in women) mean scores did not vary according to 10-y weight outcome. However, surgical patients who had gained weight or lost <10% of their baseline weight at 10 y follow-up reported higher disinhibition and hunger at each postoperative assessment (all *P* < 0.001 in both sexes) than did those who had lost more weight. Cognitive restraint scores did not reveal such a clear pattern of differences between 10-y weight-outcome groups (Figure 2). Results displayed in Figure 2 remained essentially the same after adjustment for the type of surgery in both sexes (data not shown). In addition, associations followed a similar pattern in the 3 operation groups because of overall lack of interactions between the surgery type and 10-y weight outcome groups.

Pretreatment and posttreatment levels of eating behaviors as predictors of weight changes

Eating behaviors assessed before treatment did not generally predict short- or long-term weight changes in surgically treated patients (Table 3). Six-month and 1-y levels of cognitive restraint were also unrelated to later weight changes (because effects of 6-mo and 1-y eating behaviors were highly similar, the former ones were omitted from Table 3). However, lower levels



TABLE 2Eating behaviors before treatment and after 1 and 10 y in surgically and conventionally treated patients¹

	Restraint			Disinhibition			Hunger		
	Surgical	Conventional	P	Surgical	Conventional	P	Surgical	Conventional	P
Men									
Level									
Pretreatment	6.5 ± 4.0 ²	8.2 ± 4.8	<0.001	9.2 ± 3.5	7.9 ± 3.5	<0.001	7.7 ± 3.6	6.6 ± 3.6	<0.001
1-y follow-up	12.2 ± 4.4	9.8 ± 5.1	<0.001	4.2 ± 3.1	7.1 ± 3.5	<0.001	3.0 ± 3.0	5.3 ± 3.6	<0.001
10-y follow-up	9.3 ± 4.6	9.6 ± 4.6	0.046	4.3 ± 3.1	5.8 ± 3.4	<0.001	3.5 ± 3.2	4.6 ± 3.5	<0.001
Change									
1-y change	5.7 ± 4.9	1.5 ± 4.1	<0.001	-5.0 ± 3.8	-0.8 ± 2.4	<0.001	-4.8 ± 3.8	-1.3 ± 2.8	<0.001
Effect size	1.16	0.37	—	1.32	0.33	—	1.26	0.46	—
10-y change	2.7 ± 4.4	1.2 ± 4.9	0.046	-4.9 ± 3.5	-2.0 ± 3.1	<0.001	-4.2 ± 3.7	-1.9 ± 3.2	<0.001
Effect size	0.61	0.24	—	1.40	0.65	—	1.14	0.59	—
Women									
Level									
Pretreatment	9.5 ± 4.2	10.5 ± 4.6	<0.001	9.7 ± 3.6	9.0 ± 3.7	<0.001	7.2 ± 3.5	6.4 ± 3.5	<0.001
1-y follow-up	14.0 ± 4.0	12.0 ± 4.6	<0.001	4.5 ± 3.0	8.1 ± 3.8	<0.001	2.9 ± 2.8	5.5 ± 3.6	<0.001
10-y follow-up	11.5 ± 4.5	11.3 ± 4.5	0.002	5.2 ± 3.5	6.8 ± 3.8	<0.001	3.7 ± 3.3	4.8 ± 3.6	<0.001
Change									
1-y change	4.5 ± 4.6	1.4 ± 4.1	<0.001	-5.1 ± 3.6	-0.9 ± 2.6	<0.001	-4.2 ± 3.5	-0.9 ± 2.6	<0.001
Effect size	0.98	0.34	—	1.42	0.35	—	1.20	0.35	—
10-y change	1.9 ± 4.6	0.9 ± 4.4	0.002	-4.5 ± 3.5	-2.3 ± 3.1	<0.001	-3.4 ± 3.5	-1.6 ± 3.1	<0.001
Effect size	0.41	0.20	—	1.29	0.74	—	0.97	0.52	—

¹*n* = 415–589 for men and *n* = 1062–1420 for women in the surgical group, *n* = 360–564 for men and *n* = 837–1351 for women in the conventional group. ANOVA/ANCOVA models were used to assess differences between surgical and conventional patients. Baseline level was adjusted in the analysis of longitudinal treatment effects. The effect size of within-group change over time was calculated as the mean changes between assessments divided by the SD of change (28). Effect size was judged against criteria proposed by Cohen (29) as trivial (0 to <0.20), small (0.20 to <0.50), moderate (0.50 to <0.80), and large (≥0.80).

²Mean ± SD (all such values). Higher scores indicate a greater tendency for cognitive restraint, disinhibition, and hunger.

of 6-mo [$\beta = 0.13$ – 0.27 ($P < 0.01$) in men and 0.11 – 0.22 ($P < 0.001$) in women] and 1-y [$\beta = 0.20$ – 0.29 ($P < 0.001$) in men and 0.14 – 0.28 ($P < 0.001$) in women] disinhibition and hunger were related to greater short- and long-term weight loss, and the size of these effects varied from small to close to moderate (29). Only a few relations were observed between pretreatment, 6-mo, or 1-y levels of eating behaviors and subsequent weight changes in conventionally treated patients (Table 3). Subjects with lower baseline cognitive restraint scores were more likely to have lost weight at 2-, 6-, and 10-y follow-ups than did subjects with higher scores, but these associations were small in magnitude.

Selected multigroup analyses were conducted to test whether associations between eating behaviors (pretreatment and 1-y cognitive restraint and disinhibition) and weight outcomes (2- and 10-y changes in weight) differed between banding, VBG, and GBP groups. In these analyses, the fit of a constrained model (a regression coefficient estimate was fixed to be the same across groups) was compared with the fit of an unconstrained model (an estimate was allowed to vary across groups) by using a chi-square difference test. Nonsignificant results (Δ chi-square test = 0.11 – 6.65 , Δ df = 1, $P = 0.036$ – 0.946 with 7 of 8 P values > 0.200) indicated that associations did not vary according to the performed surgical procedure.

One-year changes in eating behaviors as predictors of weight changes

Table 4 summarizes results from LGM analyses that tested effects of 1-y changes in eating behaviors on 2-, 6-, and 10-y weight outcomes (also see Figure 1). All estimated models had

a satisfactory fit with data in the surgical (chi-square test = 279.11 – 350.58 , $P < 0.001$; CFI = 0.92 – 0.94 ; RMSEA = 0.08 – 0.09 ; SRMR = 0.04) and conventional (chi-square = 197.31 – 238.44 , $P < 0.001$; CFI = 0.97 ; RMSEA = 0.07 – 0.08 ; SRMR = 0.03) groups. In surgical patients, 1-y changes in restrained eating were mainly unrelated to subsequent weight outcomes (the only exception was a small but significant effect on the 10-y weight change in women). Changes in disinhibition and hunger had moderate to large effects on weight outcomes [$\beta = 0.31$ – 0.48 ($P < 0.001$) in men and 0.24 – 0.51 ($P < 0.001$) in women] whereby patients who experienced larger 1-y decreases in disinhibition and hunger tended to lose more weight 2, 6, and 10 y after surgery. In conventional patients, higher 1-y increases in restrained eating predicted greater 2-y weight reduction in both sexes, whereas larger 1-y decreases in disinhibition and hunger were associated with greater 2-y weight loss only in women. Finally, changes in eating behaviors were unrelated to 6- and 10-y weight outcomes in the conventional group.

DISCUSSION

To our knowledge, this is the first study to document 10-y changes in psychological eating behaviors after surgical and conventional treatments of severe obesity and examine their impact on short- and long-term posttreatment weight outcomes. As expected, the surgery group lost more weight and reported larger decreases in subjective feelings of hunger and susceptibility to eat in response to various cues (e.g., scent and sight of food, negative emotions, and social events) at 1- and 10-y follow-ups than did the control group. In surgically treated patients,



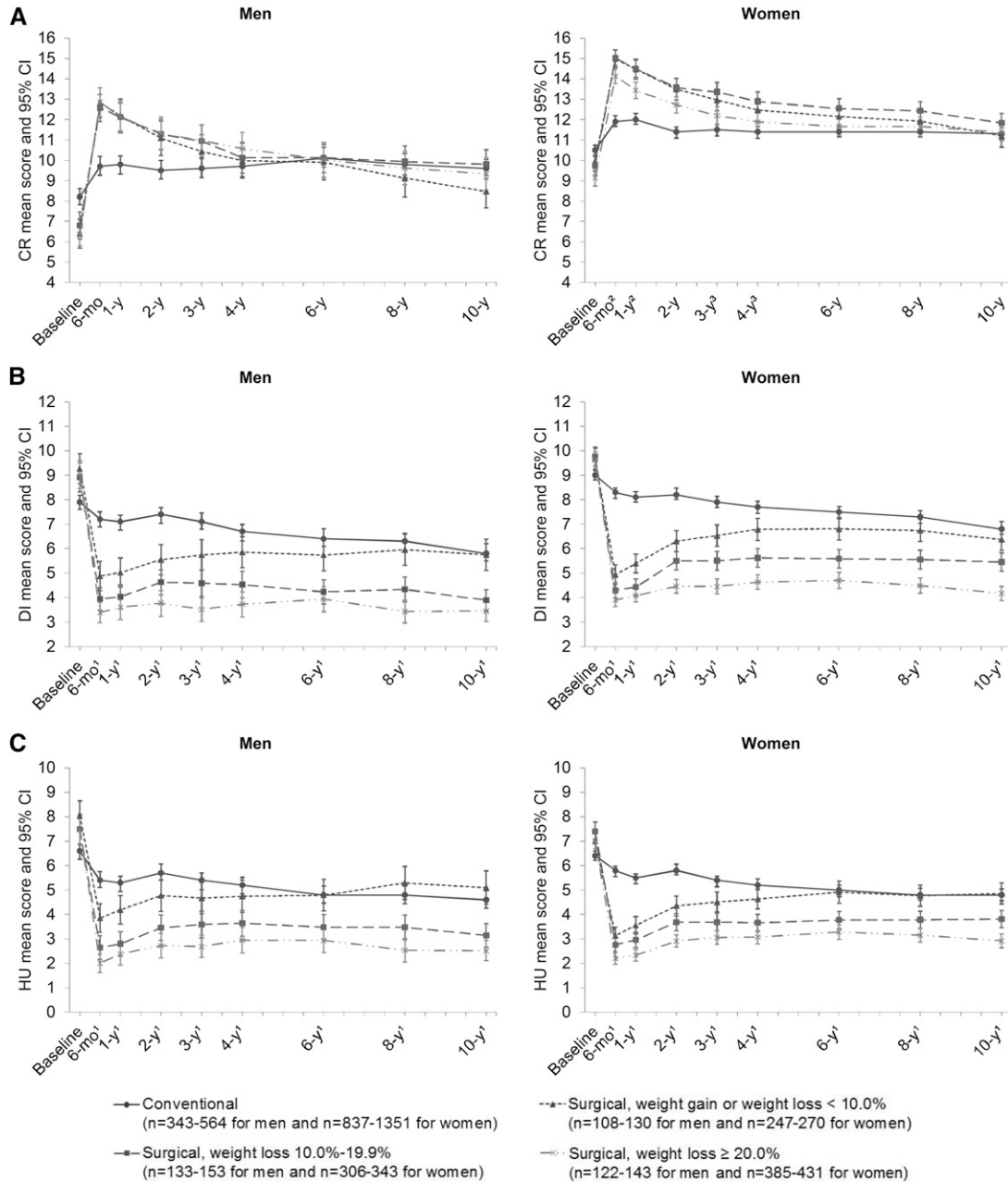


FIGURE 2 CR (A), DI (B), and HU (C) mean scores (95% CIs) during the study period according to 10-y weight change outcomes (weight gain or weight loss <10.0%, weight loss from 10.0% to 19.9%, and weight loss ≥ 20.0%) in surgically treated patients. ANOVA and ANCOVA models were used to assess differences between the three 10-y weight-outcome groups. Baseline levels were adjusted in the analysis of longitudinal treatment effects. ¹⁻³For a null hypothesis that $\mu_1 = \mu_2 = \mu_3$: ¹ $P < 0.001$, ² $P < 0.01$, ³ $P < 0.05$. Overall mean scores and 95% CIs are shown for conventionally treated patients. CR, cognitive restraint; DI, disinhibition; HU, hunger.

lower 6-mo and 1-y levels of disinhibition and hunger as well as greater 1-y decreases in these behaviors predicted more-successful short- and long-term weight loss, whereas in conventionally treated patients, weight changes were mainly related to the cognitive restraint of eating.

In the surgery group, large 1-y decreases in disinhibition and hunger remained rather stable during successive follow-up years, whereas large 1-y increases in cognitive restraint diminished gradually over time. Our short-term findings are mostly consistent with several previous studies that reported 1- to 2-y (14, 16, 18, 19, 30) or a maximum of 6-y (31) postoperative changes in the TFEQ. Because bariatric surgery alters various physiologic

mechanisms related to appetite, satiety, and taste (32, 33), it was reasonable that the greatest average long-term changes were observed in disinhibition and hunger.

An important observation was that bariatric surgery was not equally effective in all subjects in reducing difficulties related to the regulation of eating, and these differences were linked to 10-y weight outcomes whereby subjects who gained weight or lost <10% of their baseline weights reported less improvements in disinhibition and hunger than did those with greater 10-y weight losses. In line with a few other studies (14–16), it was not possible to anticipate postoperative weight outcomes on the basis of preoperative eating behaviors. However, smaller decreases in



TABLE 3

Results from the structural equation models predicting percentage of weight change from pretreatment weight in surgically and conventionally treated patients¹

	Men (n = 564–590)			Women (n = 1352–1420)		
	2-y change	6-y change	10-y change	2-y change	6-y change	10-y change
Surgical						
Pretreatment						
Restraint	0.02 ± 0.04	−0.01 ± 0.05	0.03 ± 0.05	0.08 ± 0.03 ^b	0.06 ± 0.03 ^c	0.10 ± 0.03 ^b
Disinhibition	0.05 ± 0.04	0.05 ± 0.05	0.03 ± 0.05	0.06 ± 0.03 ^c	0.05 ± 0.03	0.06 ± 0.03
Hunger	0.06 ± 0.04	0.02 ± 0.05	0.02 ± 0.05	0.05 ± 0.03	0.05 ± 0.03	0.03 ± 0.03
1-y follow-up						
Restraint	0.02 ± 0.04	0.10 ± 0.05 ^c	0.02 ± 0.05	0.04 ± 0.03	0.04 ± 0.03	0.08 ± 0.03 ^c
Disinhibition	0.28 ± 0.04 ^a	0.22 ± 0.05 ^a	0.20 ± 0.05 ^a	0.28 ± 0.03 ^a	0.16 ± 0.03 ^a	0.18 ± 0.03 ^a
Hunger	0.29 ± 0.04 ^a	0.22 ± 0.05 ^a	0.24 ± 0.05 ^a	0.28 ± 0.03 ^a	0.14 ± 0.03 ^a	0.18 ± 0.03 ^a
Conventional						
Pretreatment						
Restraint	0.14 ± 0.05 ^b	0.12 ± 0.05 ^c	0.17 ± 0.05 ^b	0.18 ± 0.03 ^a	0.14 ± 0.03 ^a	0.13 ± 0.04 ^a
Disinhibition	0.09 ± 0.05	−0.03 ± 0.05	−0.05 ± 0.05	−0.02 ± 0.03	−0.02 ± 0.04	−0.04 ± 0.04
Hunger	0.09 ± 0.05	−0.04 ± 0.05	0.01 ± 0.05	−0.02 ± 0.03	0.01 ± 0.03	−0.01 ± 0.04
1-y follow-up						
Restraint	−0.14 ± 0.05 ^b	0.03 ± 0.05	0.03 ± 0.05	−0.05 ± 0.03	−0.01 ± 0.04	0.02 ± 0.04
Disinhibition	0.07 ± 0.05	−0.00 ± 0.05	−0.04 ± 0.05	0.09 ± 0.03 ^b	0.01 ± 0.04	0.00 ± 0.04
Hunger	0.07 ± 0.05	0.00 ± 0.05	0.02 ± 0.06	0.05 ± 0.03	0.04 ± 0.04	0.00 ± 0.04

¹All values are β s ± SEs. Models include the following independent variables: pretreatment age, pretreatment weight, surgery type [nonadjustable and adjustable bandings (reference category) vertical banded gastropasty, or gastric bypass], cognitive restraint (pretreatment or 1-y), and disinhibition or hunger (pretreatment or 1-y). Positive coefficients indicate that lower levels of cognitive restraint, disinhibition, and hunger were related to greater weight loss, whereas negative coefficients reflect the opposite pattern. The effect size was judged against criteria proposed by Cohen (29) for correlation/regression coefficients as small (0.10 to <0.30), moderate (0.30 to <0.50), and large (≥ 0.50). ^{a-c}For a null hypothesis that $\beta = 0$: ^a $P < 0.001$, ^b $P < 0.01$, ^c $P < 0.05$.

disinhibition and hunger during the first postsurgical year as well as respective higher 6-mo and 1-y levels of these behaviors were important determinants of less-successful weight loss even 10 y after surgery. In contrast, deliberate efforts to restrict food intake as measured by the cognitive restraint scale were not linked to short- or long-term postsurgical changes in weight. Our study extends the findings of White et al. (34) who showed, in 361 GBP patients that

those reporting a loss of control over eating 6 mo (31% of the patients) and 1 y (39% of patients) after the operation lost significantly less weight at 1- and 2-y follow-ups, whereas a preoperative lack of control was unrelated to weight outcomes.

Although it remains to be elucidated why some surgical patients experienced less improvements in susceptibility for uncontrolled eating, the current results suggest that a self-assessment instrument

TABLE 4

Results from the latent growth models predicting percentage of weight change from pretreatment weight in surgically and conventionally treated patients¹

	Men (n = 564–590)			Women (n = 1352–1420)		
	2-y change	6-y change	10-y change	2-y change	6-y change	10-y change
Surgical						
1-y rate of change						
Restraint	0.09 ± 0.07	0.13 ± 0.08	0.08 ± 0.08	0.06 ± 0.04	0.06 ± 0.05	0.12 ± 0.05 ^c
Disinhibition	0.47 ± 0.08 ^a	0.31 ± 0.09 ^a	0.36 ± 0.09 ^a	0.45 ± 0.04 ^a	0.26 ± 0.05 ^a	0.27 ± 0.05 ^a
Hunger	0.48 ± 0.07 ^a	0.37 ± 0.08 ^a	0.40 ± 0.08 ^a	0.51 ± 0.05 ^a	0.24 ± 0.06 ^a	0.31 ± 0.06 ^a
Conventional						
1-y rate of change						
Restraint	−0.35 ± 0.06 ^a	−0.05 ± 0.07	−0.09 ± 0.07	−0.18 ± 0.05 ^a	−0.10 ± 0.06	−0.05 ± 0.06
Disinhibition	0.03 ± 0.06	0.08 ± 0.07	0.04 ± 0.08	0.23 ± 0.05 ^a	0.07 ± 0.05	0.10 ± 0.06
Hunger	0.01 ± 0.07	0.03 ± 0.08	−0.01 ± 0.08	0.15 ± 0.05 ^b	0.06 ± 0.05	0.04 ± 0.06

¹All values are β s ± SEs. See Figure 1 for variables included in models. Positive coefficients indicate that smaller 1-y increases in cognitive restraint and larger 1-y decreases in disinhibition and hunger were related to greater weight loss, whereas negative coefficients reflect the opposite pattern. The effect size was judged against criteria proposed by Cohen (29) for correlation/regression coefficients as small (0.10 to <0.30), moderate (0.30 to <0.50), and large (≥ 0.50). ^{a-c}For a null hypothesis that $\beta = 0$: ^a $P < 0.001$, ^b $P < 0.01$, ^c $P < 0.05$.

such as the TFEQ can be used for screening of patients who may need more-intensive counseling and support after the operation. The physiologic control mechanisms induced by the surgery aid patients to make initial changes in eating behaviors, but these mechanisms tend to weaken over time and do not guarantee long-term success in lifestyle changes (35). Qualitative studies (36, 37) have suggested that surgical candidates often initially perceive the operation as an external solution that will change their lives without requiring their own active participation, reflecting that there is a need to systematically ensure that patients have realistic expectations regarding the surgery and receive adequate support to make permanent lifestyle changes.

Only minor average weight changes occurred after conventional obesity treatment, but there was considerable variability between patients. Small increases in cognitive restraint and moderate decreases in disinhibition and hunger were observed 10 y after the start of the study, which may have indicated an overall shift toward healthier food-intake patterns (38). A robust observation in previous lifestyle intervention research has been that decreases in overeating tendencies and increases in cognitive restraint are positively associated with short-term weight loss and maintenance (39–41), and this effect was also the case in our study, especially in women. At 10-y follow-up, a small proportion of the conventionally treated patients had lost $\geq 10\%$ of their baseline weight, and the majority had gained weight, but these variations in 10-y weight outcomes were unrelated to initial 1-y changes in eating behaviors. Nevertheless, higher pretreatment restrained eating had a small negative effect on short- and long-term weight reductions in accordance with population-based 3- and 6-y prospective studies (42, 43). It may be that patients who restricted their eating more at baseline were mainly those who had the greatest vulnerability to gain weight and were trying to counteract this disposition (44).

Conventional treatment was not standardized and was carried out across primary healthcare centers without extra resources for obesity treatment, which may partly explain the modest short-term weight reduction in conventionally treated patients. Moreover, short-term changes in weight and TFEQ may have been underestimated because the conventional group lost weight during the period between matching and the inclusion examination (21), which indicated that behavioral changes were made already before the treatment.

Because the TFEQ was not developed for bariatric surgery patients, other eating behaviors that might be particularly relevant after surgical treatment deserve attention. Grazing is one such behavior that refers to the continuous consumption of smaller amounts of food over extended periods of time, but relatively few studies have examined whether this predicts postsurgical outcomes [for exceptions, see Colles et al. (45)]. Note that disinhibition and hunger scales are likely to address aspects of the same underlying phenomenon, i.e., uncontrolled eating in response to internal and external eating stimulus (46), as reflected in their high intercorrelations as well as comparable pattern of associations in both treatment groups.

Strengths of the study included an exceptionally long and frequent posttreatment follow-up and adequate response rate over time. In addition, a large sample enabled separate analyses for men and women. Although associations tended to be parallel in both sexes, earlier small-scale studies have rarely been able to show this relation. The use of the FIML method to handle missing

data and LGM to model individual differences in 1-y changes in eating behaviors represent other strengths of the study. Nonetheless, sensitivity analyses that used only participants with no missing data as well as the use of 1-y difference scores of TFEQ scales (with adjustment for baseline levels) to predict changes in weight produced comparable estimates (data not shown). Because the SOS study was initiated already in the 1980s, a potential limitation of the study was that the majority of the patients were operated with surgical procedures, which are infrequently used nowadays (47). This difference might have affected the generalizability of our findings. Banding was related to higher postoperative disinhibition, hunger, and cognitive restraint scores than was particularly GBP, which suggested that lower reductions in uncontrolled eating may partly explain why banding is less effective in producing weight loss than is GBP (48). However, despite these differences, eating behaviors predicted weight changes similarly in the 3 surgery groups as indicated by the selected multigroup analyses.

In conclusion, a higher vulnerability to various internal and external eating cues shortly after the operation was the focal predictor of less successful short- and long-term weight loss in surgically treated patients, whereas in conventionally treated patients, weight outcomes were primarily linked to conscious efforts to limit food intake. The current results imply that especially the first year after surgery is a critical period for monitoring patients' eating behaviors to recognize those who need more-intensive postsurgical support and counseling. An essential objective for additional research is to clarify what are the best intervention strategies to aid patients who experience postoperative problems in the regulation of eating to obtain long-term improvements in physical and mental well-being.

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