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Bariatric surgery-induced weight loss causes remission of food addiction in extreme obesity

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Abstract

Objective—To test the hypotheses that bariatric surgery-induced weight loss: 1) induces remission of food addiction (FA), and 2) normalizes other eating behaviors associated with FA.

Design and Methods—Forty-four obese subjects (BMI= 48±8 kg/m^2) were studied before and after ~20% weight loss induced by bariatric surgery (25 Roux-en-Y gastric bypass, 11 laparoscopic adjustable gastric banding, and 8 sleeve gastrectomy). We assessed: 1) FA (Yale Food Addiction Scale), 2) food cravings (Food Craving Inventory) and 3) restrictive, emotional and external eating behaviors (Dutch Eating Behavior Questionnaire).

Results—FA was identified in 32% of subjects before surgery. Compared with non-FA subjects, those with FA craved foods more frequently, and had higher scores for emotional and external eating behaviors (all P-values <0.01; all Cohen's d >0.8). Surgery-induced weight loss resulted in remission of FA in 93% of FA subjects; no new cases of FA developed after surgery. Surgery-induced weight loss decreased food cravings, and emotional and external eating behaviors in both groups (all P-values <0.001; all Cohen's d≥0.8). Restrictive eating behavior did not change in non-FA subjects but increased in FA subjects (P<0.01; Cohen's d>1.1).

Conclusion—Bariatric surgery-induced weight loss induces remission of FA and improves several eating behaviors that are associated with FA.

Keywords

Obesity Surgery; Food; Eating Behavior; Eating Disorders

Introduction

Obesity has become a major public health problem in the United States and many countries worldwide, because of its high prevalence, association with serious medical illnesses, and

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Conflict of interest. SK is a shareholder of Aspire Bariatrics, Metro Midwest Biotech and Human Longevity Inc, serves or served as a consultant to Aspire Bariatrics, Takeda Pharmaceuticals, Danone/Yakult, NovoNordisk, Merck, and the Egg Nutrition Council. RS served as a consultant to Aspire Bariatrics and serves as a consultant to USGI Medical.

economic costs. Obesity is caused by a complex interaction among genetic, environmental, central neural, and lifestyle factors that result in ingesting more energy than is expended over a long period of time, and storing the excess energy as body fat. The increase in food intake must then be maintained in obese people to maintain the increase in body size. It has been proposed that addictive-like eating behavior or "food addiction" (FA) is responsible for excessive food intake and increased adiposity in a subset of obese people (1–6).

The American Society of Addiction Medicine defines addiction as "a primary, chronic disease of brain reward, motivation, memory and related circuitry" (7). Dysfunction in these circuits causes a compulsive pursuit of reward by substance use or other behaviors, even though the behavior has serious adverse clinical consequences (7). The recent Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM V; (8)) now includes Substance-Related and Addictive Disorders as a category, and notes both substance use disorder and gambling behavior as addictions. Although FA is not recognized as an addictive disorder by DSM V, data from a series of studies demonstrate that addiction to food can be experimentally induced in rodents. Intermittent access to sugar or highly palatable diets elicits behavioral signs of addiction, including withdrawal and cross-sensitization, and neurochemical adaptations in brain-reward systems that are similar to those found after repeated administration of drugs of abuse, such as amphetamine, cocaine or opiates (e.g., 9, 10). There is also evidence to support the notion that addictive-like eating behavior exist in people (4), and a psychometrically sound tool, the Yale Food Addiction Scale (YFAS), has been developed to diagnose FA (5, 11, 12, 13). Approximately 30% of obese people meet criteria for FA, determined by using the YFAS (3, 4, 13). These people exhibit behavioral characteristics associated with addiction, such as greater impulsivity and emotional reactivity (3, 5), and crave food more frequently (3, 14), are more likely to engage in binge eating, hedonic eating, and emotional eating than subjects who do not meet criteria for FA (non-FA) (3, 11).

Bariatric surgery is the most effective available weight loss therapy for obesity and has profound effects on the drive to eat (15, 16). Data from several studies have shown that weight loss induced by Roux-en-Y gastric bypass (RYGB) or laparoscopic adjustable gastric banding (LAGB) is associated with reduced food cravings and reduced emotional and external eating behavior (16, 17). However, it is not known whether bariatric surgery-induced weight loss can affect FA in patients who meet diagnostic criteria for FA before surgery.

The purpose of the present longitudinal study was to test the hypotheses that weight loss induced by the three most commonly performed bariatric surgery procedures, RYGB, LAGB, and sleeve gastrectomy (SG), induce remission of FA, as diagnosed by the YFAS, and normalize eating behaviors associated with FA. We evaluated obese subjects before bariatric surgery and after they lost ~20% of their body weight.

Methods and Procedures

Study subjects

The study population consisted of 44 consecutive obese patients (39 women, 5 men) who were scheduled to undergo RYGB (n=25), LAGB (n=11) or SG (n=8) at Barnes-Jewish Hospital (St. Louis, MO, USA) after they lost at least 15% of their initial body weight and returned for follow-up studies within 9 months after surgery. Nine additional subjects were enrolled, but did not complete the study: four withdrew, three were lost-to-follow-up, one failed to return for the follow-up assessment within 9 months after surgery, and one decided not to have surgery. Among these non-completers, eight were in the non-FA group and one was in the FA group. All subjects met the criteria for surgery recommended by the American Society for Metabolic and Bariatric Surgery (18). We excluded potential subjects who had diabetes, smoked cigarettes, had previous intestinal surgery, inflammatory intestinal disease, severe organ dysfunction, bulimia, or substance or alcohol abuse. All subjects provided written informed consent before participating in this study, which was approved by Washington University School of Medicine's Institutional Review Board.

Experimental Protocol

Eating behavior assessment—Subjects completed the YFAS (5), the Dutch Eating Behavior Questionnaire (DEBQ; 19), and the Food Craving Inventory (FCI; 20) before and after ~20% (range 15%-28%) surgery-induced weight loss. These questionnaires were administered in a private room at the Washington University School of Medicine Clinical Research Unit.

The YFAS is a 25-item questionnaire that adapted the 7 symptoms of substance dependence listed in the DSM-IV-TR to assess addictive eating behaviors. These symptoms include: 1) substance taken in larger amount and for longer period than intended; 2) persistent desire or repeated unsuccessful attempt to quit; 3) much time/activity to obtain, use, recover; 4) important social, occupational, or recreational activities given up or reduced; 5) use continues despite knowledge of adverse consequences; 6) tolerance (marked increase in amount; marked decrease in effect); and 7) characteristic withdrawal symptoms, substance taken to relieve withdrawal) To meet a diagnosis of FA, a subject has to experience 3 or more of the 7 dependence symptoms and have had significant impairment or distress during the past year. The YFAS score is the total number of symptoms endorsed, ranging from 0 to 7 (5). The YFAS has been validated in bariatric surgery populations (11, 13).

The DEBQ measures three common psychological dimensions of eating behavior: 1) emotional eating (an inclination to eat in response to negative emotions such as depression or feelings of loneliness), 2) external eating (an inclination to eat in response to external food cues such as the smell of food), and 3) restrained eating (an inclination to consciously restrict food intake to control body weight) (19). Reference normal values are available for both men and women (21). Responses are scored by using a 5-point Likert scale (1=never, 5=very often/always).

The FCI is a validated measure of the frequency of overall food cravings, as well as cravings for specific types of foods (high fats, sweets, carbohydrates/ starches, and fast-food fats)

during the past month (20). Responses are scored by using a 5-point Likert scale (1=never, 5=very often/always). Both the DEBQ and the FCI have been validated in obese people and obese people with eating disorders (e.g. 21, 22).

Surgical Procedures

All surgical procedures were performed by using standard laparoscopic approaches. The SG procedure involved dividing the gastrocolic ligament, initiating the gastrectomy 6 cm proximal to the pylorus along the greater curve, subtotal resection of the fundus and body of the stomach, and creating the sleeve along the lesser curve over a 40 French Bougie. The RYGB procedure involved creating a small (~20 ml) proximal gastric pouch, a 30 cm biliopancreatic limb, and a 75–150 cm Roux-Y limb (23). The standard pars flaccid technique was used for LAGB (Lap-Band, Allergan, Irvin, CA, USA) (23).

Diet Management after Surgery

Subjects had individual dietary counselling to help them achieve about a 20% total weight loss within 6 months after surgery and to provide the same dietary guidelines to all subjects after surgery. Subjects were instructed to consume a liquid diet for the first week after surgery, followed by a 2–4 week progression to a regular-food diet containing 1000–1200 kcal/day and 1.0 g of protein/kg body weight/ day. A study dietitian with expertise in weight management met with the subjects, or contacted them by phone, weekly to monitor body weight, review dietary intake, provide standard weight management behavioral education and adjust recommended energy intake as needed to achieve weight loss targets. All eating behavior assessments conducted before surgery were repeated when participants lost ~20% (range 15%–28%) of their initial body weight.

Data Analyses

A McNemar’s test was used to compare the difference in the proportion of subjects meeting criteria of FA before and after surgery-induced weight loss. Two-way ANOVAs with group (FA and non-FA) as the between-subject factor and time (before-after surgery) were used to determine whether group and surgery-induced weight loss were associated with differences in food cravings and eating behavior. When the ANOVAs revealed a significant interaction effect, post-hoc Bonferroni comparisons were conducted. In addition, one-sample t-tests were used to compare DEBQ scores of FA and non-FA subjects with norm values. The magnitude of group differences was further determined by calculating effects sizes (ES) using Cohen's d (24). ES translate differences between two groups into a standard unit of measurement and make it possible to interpret the importance of a group difference (24). ES were judged against standard criteria proposed by Cohen: trivial (<0.2), small (0.2<0.5), medium (0.5<0.8) and large (≥0.8). Data in the tables and figures are presented as means ± SD unless otherwise indicated. All analyses were performed with STATISTICA 8.0 (StatSoft, Tulsa OK), and the criterion for statistical significance was $P < 0.05$.

RESULTS

Subject characteristics

FA was identified in 14 of 44 subjects (32%) before surgery. There were no significant differences in factors that could affect FA, specifically age, race, level of formal education, and income level between non-FA and FA groups (Table 1). There were no significant differences between groups in the timing of the follow-up studies after surgery (Non-FA=19.7 ± 6.4 weeks and FA= 20.4 ± 6.3 weeks; P>0.5).

Effect of surgery-induced weight loss on food addiction

Subjects were evaluated before and after 20 ± 3 % weight loss. Surgery-induced weight loss resulted in remission of FA in 13 of the 14 subjects (93%) who met criteria for FA before surgery; no new cases of FA were identified after surgery. Therefore, the prevalence of food addiction in this study population decreased from 32% to 2% (P<0.00001) (Figure 1). Surgery-induced weight loss reduced the median number of FA symptoms in all subjects (P<0.0001). FA subjects had more symptoms than did non-FA subjects before surgery (Median ± SIQR: 5.0 ± 1.0 vs. 2.0 ± 0.5; P<0.0001), and tended to still be greater after surgery-induced weight loss (Median ± SIQR 2.0 ± 1.0 vs. 1.0 ± 1.0; P=0.06), but the difference between groups was not statistically significant (P=0.06)

Effect of surgery-induced weight loss on food cravings

Surgery-induced weight loss decreased food cravings in both FA and non-FA groups, but the decrease was greater in FA than non-FA subjects (24±18% vs. 16±17%; P<0.05). FA subjects craved foods more frequently than did non-FA subjects before, but not after surgery-induced weight loss (Figure 2). Subjects with FA craved more starches and fast-food fats than non-FA subjects did before surgery. Although surgery-induced weight loss decreased cravings for all types of foods, cravings for starchy foods were still more frequent in FA than in non-FA subjects after surgery (P=0.009; Figure 3).

Effect of surgery-induced weight loss on eating behavior

Surgery-induced weight loss decreased emotional and external eating behaviors in both FA and non-FA groups, but increased restrained eating behavior to above normative values in FA subjects only (all P-values <0.05; all Cohen's d≥0.8; Figure 4). Before surgery, FA subjects scored higher than did non-FA subjects in emotional and external eating behaviors, but these scores became normal after surgery-induced weight loss (Figure 4).

Discussion

The mechanisms responsible for excessive food intake in obese people are complex. It has recently been proposed that some obese people have an addiction to food, manifested as repetitive food intake activation of brain reward systems that causes continued harmful eating behavior despite serious health consequences (1–7). In the present study we found that FA, as diagnosed by the YFAS, occurs in about one-third of obese patients undergoing bariatric surgery and that bariatric surgery-induced weight loss resulted in remission of FA in 93% of patients. Moreover, surgery-induced weight loss normalized other eating

behaviors associated with food addiction, including food cravings and emotional and external eating behavior scores. We did not detect any differences in the ability of different surgical procedures (RYGB, SG, or LAGB) to induce remission of FA. However, our study was not adequately powered to detect differences between surgery procedures. These data suggest that bariatric surgery-induced weight loss is an effective therapy for FA and abnormal eating behaviors associated with FA.

After bariatric-surgery induced weight loss, restrained eating increased in FA subjects but did not change in non-FA subjects. Data from previous studies have shown that restrained eating is associated with higher dopamine responsivity to food cues (25) and increased hedonic hunger (26). Therefore, the increased restrained eating behavior adopted after surgery might reflect a cognitive strategy used by FA subjects to help them counteract their still heightened sensitivity to the rewarding value of food.

The prevalence of FA in our study subjects (32%) is similar to the prevalence recently reported in a large cohort of women, 45–49 years of age and a BMI ≥35 kg/m^2 (26%) (4). In that study the prevalence of FA was ~17-fold higher in women with a BMI ≥ 35 kg/m^2 than in women with a BMI between 18.5 and 22.9 kg/m^2. Although we excluded potential participants who had bulimia, we did not determine whether our subjects had binge eating disorder (BED), which is associated with FA (3, 12) and is improved by bariatric surgery (27). Our findings demonstrate that weight loss can induce remission of FA, even though subjects are still obese. These data suggest that obesity itself does not cause FA, but that FA is a contributing, but modifiable, risk factor for obesity.

Although bariatric surgery is an effective weight loss therapy, not all patients achieve successful weight loss and lose less than 10% of their body weight, or lose weight initially but regain much of their lost weight over time (28). It is not known whether the presence of FA influences the ability of bariatric surgery to cause weight loss. We are aware of two studies that evaluated the effect of FA on the ability of diet therapy to cause weight loss (29, 30), which demonstrate conflicting results. In one study, features of FA were negatively correlated with weight loss after a 7-week behavioral weight loss intervention (29), whereas in the other study, FA status had no effect on weight loss after a 6-month weight loss program (30). The therapeutic effect of RYGB surgery-induced weight loss on FA observed in our subjects contrasts the growing body of evidence suggesting patients who have had RYGB surgery are at increased risk of developing a substance-use disorder (SUD) (31, 32). Moreover, data from a recent study found a significant association between presurgical FA and postoperative SUD (33). Data from a study conducted in a rodent model found that RYGB increases the reward effect of alcohol, independent of alcohol absorption (34), suggesting RYGB surgery can cause central changes in reward circuits. In total, these findings support the notion of “addiction transfer”, and highlight the need for additional studies to determine whether patients who have FA before surgery should be given specific postsurgical interventions to prevent SUD.

Data from several (1, 35, 36), but not all (37), studies have demonstrated that obesity is associated with a reduction in brain dopaminergic receptor availability, which is an important component of the central reward mechanism (1) and is associated with substance

addiction (2). However, it is not clear whether the dopaminergic receptor system, which is likely involved in FA (38), is affected by bariatric surgery-induced weight loss, because of conflicting results from different studies, which found an increase (39), decrease (40), and no change (36) in dopamine receptor binding after gastric bypass surgery.

Our study has several important limitations. First, we are not able to determine whether behaviors after bariatric surgery were caused by true psychological changes or reflect the dietary response to changes in gastrointestinal anatomy. Second, by providing dietary counselling after surgery to help ensure compliance with the recommended post-operative diet and facilitate weight loss, we might have inadvertently influenced the subjects' scores of the eating behavior assessments. Third, the YFAS has been validated in bariatric surgery populations (11, 13), but more detailed assessments of the psychometric properties of this tool in subjects who have had bariatric surgery are needed. Fourth, the exclusion of subjects with diabetes avoids the potential confounding effect of changes in glucose control and diabetes medications on our outcome measures, but means our findings might not translate to patients with diabetes.

In conclusion, bariatric surgery-induced weight loss induces remission of FA, as diagnosed by the YFAS, and improves eating behaviors associated with FA in extremely obese people. Additional studies are needed to determine the mechanism(s) responsible for FA remission, and to determine whether the presence of FA influences the weight loss efficacy of bariatric surgery.

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REFERENCES

1. Wang GJ, Volkow ND, Logan J, Pappas NR, Wong CT, Zhu W, et al. Brain dopamine and obesity. Lancet. 2001; 357:354–357. [PubMed: 11210998]
2. Volkow ND, Wang GJ, Fowler JS, Tomasi D, Baler R. Food and drug reward: overlapping circuits in human obesity and addiction. Curr Top Behav Neurosci. 2012; 11:1–24. [PubMed: 22016109]
3. Davis C, Curtis C, Levitan RD, Carter JC, Kaplan AS, Kennedy JL. Evidence that 'food addiction' is a valid phenotype of obesity. Appetite. 2011; 57:711–717. [PubMed: 21907742]
4. Flint AJ, Gearhardt AN, Corbin WR, Brownell KD, Field AE, Rimm EB. Food-addiction scale measurement in 2 cohorts of middle-aged and older women. Am J Clin Nutr. 2014; 99:578–586. [PubMed: 24452236]
5. Gearhardt AN, Corbin WR, Brownell KD. Preliminary validation of the Yale Food Addiction Scale. Appetite. 2009; 52:430–436. [PubMed: 19121351]
6. Avena NM, Bocarsly ME, Hoebel BG, Gold MS. Overlaps in the nosology of substance abuse and overeating: the translational implications of "food addiction". Current drug abuse reviews. 2011; 4:133–139. [PubMed: 21999687]
7. Smith DE. The process addictions and the new ASAM definition of addiction. Journal of psychoactive drugs. 2012; 44:1–4. [PubMed: 22641960]
8. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed.. Arlington, VA: American Psychiatric Publishing; 2013.

9. Avena NM, Hoebel BG. A diet promoting sugar dependency causes behavioral crosssensitization to a low dose of amphetamine. Neuroscience. 2003; 122:17–20. [PubMed: 14596845]
10. Johnson PM, Kenny PJ. Dopamine D2 receptors in addiction-like reward dysfunction and compulsive eating in obese rats. Nat Neurosci. 2010; 13:635–641. [PubMed: 20348917]
11. Clark SM, Saules KK. Validation of the Yale Food Addiction Scale among a weight-loss surgery population. Eat Behav. 2013; 14:216–219. [PubMed: 23557824]
12. Gearhardt AN, White MA, Masheb RM, Morgan PT, Crosby RD, Grilo CM. An examination of the food addiction construct in obese patients with binge eating disorder. Int J Eat Disord. 2012; 45:657–663. [PubMed: 22684991]
13. Meule A, Heckel D, Kubler A. Factor structure and item analysis of the Yale Food Addiction Scale in obese candidates for bariatric surgery. Eur Eat Disord Rev. 2012; 20:419–422. [PubMed: 22761046]
14. Meule A, Kubler A. Food cravings in food addiction: the distinct role of positive reinforcement. Eat Behav. 2012; 13:252–255. [PubMed: 22664405]
15. Schultes B, Ernst B, Wilms B, Thurnheer M, Hallschmid M. Hedonic hunger is increased in severely obese patients and is reduced after gastric bypass surgery. Am J Clin Nutr. 2010; 92:277–283. [PubMed: 20519559]
16. Leahey TM, Bond DS, Raynor H, Roye D, Vithiananthan S, Ryder BA, et al. Effects of bariatric surgery on food cravings: do food cravings and the consumption of craved foods"normalize" after surgery? Surg Obes Relat Dis. 2012; 8:84–91. [PubMed: 21925967]
17. Pepino MY, Bradley D, Eagon JC, Sullivan S, Abumrad NA, Klein S. Changes in taste perception and eating behavior after bariatric surgery-induced weight loss in women. Obesity (Silver Spring) in press.
18. Mechanick JI, Kushner RF, Sugerman HJ, Gonzalez-Campoy JM, Collazo-Clavell ML, Guven S, et al. American Association of Clinical Endocrinologist, The Obesity Society, and American Society for Metabolic & Bariatric Surger Medical Guidelines for Clinical Practice for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient. Surg Obes Relat Dis. 2008; 4:S109–S184. [PubMed: 18848315]
19. van Strien T, Frijters ER, Bergers GPA, Defares PB. The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. International Journal of Eating Disorders. 1986; 5:295–315.
20. White MA, Whisenhunt BL, Williamson DA, Greenway FL, Netemeyer RG. Development and validation of the food-craving inventory. Obes Res. 2002; 10:107–114. [PubMed: 11836456]
21. van Strien, T. Dutch eating behaviour questionnaire: manual. London: Pearson; 2002.
22. White MA, Grilo CM. Psychometric properties of the Food Craving Inventory among obese patients with binge eating disorder. Eat Behav. 2005; 6:239–245. [PubMed: 15854870]
23. Varela JE. Bariatric surgery: a cure for diabetes? Curr Opin Clin Nutr Metab Care. 2011; 14:396–401. [PubMed: 21505331]
24. Cohen, J. Statistical Power Analysis for the Behavioral Sciences. Second Edition. Hillsdale, NJ: Lawrence Erlbaum; 1988.
25. Volkow ND, Wang GJ, Maynard L, Jayne M, Fowler JS, Zhu W, et al. Brain dopamine is associated with eating behaviors in humans. Int J Eat Disord. 2003; 33:136–142. [PubMed: 12616579]
26. Fedoroff IC, Polivy J, Herman CP. The effect of pre-exposure to food cues on the eating behavior of restrained and unrestrained eaters. Appetite. 1997; 28:33–47. [PubMed: 9134093]
27. Wadden TA, Faulconbridge LF, Jones-Corneille LR, Sarwer DB, Fabricatore AN, Thomas JG, et al. Binge eating disorder and the outcome of bariatric surgery at one year: a prospective, observational study. Obesity. 2011; 6:1220–1228. [PubMed: 21253005]
28. Sjostrom L, Lindroos AK, Peltonen M, Torgerson J, Bouchard C, Carlsson B, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. N Engl J Med. 2004; 351:2683–2693. [PubMed: 15616203]
29. Burmeister JM, Hinman N, Koball A, Hoffmann DA, Carels RA. Food addiction in adults seeking weight loss treatment. Implications for psychosocial health and weight loss. Appetite. 2013; 60:103–110. [PubMed: 23017467]

30. Lent MR, Eichen DM, Goldbacher E, Wadden TA, Foster GD. Relationship of food addiction to weight loss and attrition during obesity treatment. Obesity (Silver Spring). 2014; 22:52–55. [PubMed: 23776067]

31. Saules KK, Wiedemann A, Ivezaj V, Hopper JA, Foster-Hartsfield J, Schwarz D. Bariatric surgery history among substance abuse treatment patients: prevalence and associated features. Surg Obes Relat Dis. 2010; 6:615–621. [PubMed: 20207591]

32. King WC, Chen JY, Mitchell JE, Kalarchian MA, Steffen KJ, Engel SG, et al. Prevalence of alcohol use disorders before and after bariatric surgery. JAMA. 2012; 307:2516–2525. [PubMed: 22710289]

33. Reslan S, Saules KK, Greenwald MK, Schuh LM. Substance Misuse Following Roux-en-Y Gastric Bypass Surgery. Substance use & misuse. 2014; 49:405–417. [PubMed: 24102253]

34. Polston JE, Pritchett CE, Tomasko JM, Rogers AM, Leggio L, Thanos PK, et al. Rouxen-Y gastric bypass increases intravenous ethanol self-administration in dietary obese rats. PLoS One. 2013; 8:e83741. [PubMed: 24391816]

35. Volkow ND, Wang GJ, Telang F, Fowler JS, Thanos PK, Logan J, et al. Low dopamine striatal D2 receptors are associated with prefrontal metabolism in obese subjects: possible contributing factors. Neuroimage. 2008; 42:1537–1543. [PubMed: 18598772]

36. de Weijer BA, van de Giessen E, Janssen I, Berends FJ, van de Laar A, Ackermans MT, et al. Striatal dopamine receptor binding in morbidly obese women before and after gastric bypass surgery and its relationship with insulin sensitivity. Diabetologia. 2014; 57:1078–1080. [PubMed: 24500343]

37. Eisenstein SA, Antenor-Dorsey JA, Gredysa DM, Koller JM, Bihun EC, Ranck SA, et al. A comparison of D2 receptor specific binding in obese and normal-weight individuals using PET with (N-[(11)C]methyl)benperidol. Synapse. 2013; 67:748–756. [PubMed: 23650017]

38. Gearhardt AN, Yokum S, Orr PT, Stice E, Corbin WR, Brownell KD. The neural correlates of “Food Addiction”. Arch Gen Psychiatry. 2011; 8:808–816. [PubMed: 21464344]

39. Steele KE, Prokopowicz GP, Schweitzer MA, Magunsuon TH, Lidor AO, Kuwabawa H, et al. Alterations of central dopamine receptors before and after gastric bypass surgery. Obes Surg. 2010; 20:369–374. [PubMed: 19902317]

40. Dunn JP, Cowan RL, Volkow ND, Feurer ID, Li R, Williams DB, et al. Decreased dopamine type 2 receptor availability after bariatric surgery: preliminary findings. Brain Res. 2010; 1350:123–130. [PubMed: 20362560]

What is already known about this subject

- Obesity is associated with a higher prevalence of food addiction (FA).
- Subjects meeting criteria for FA crave food more frequently, and are more likely to engage in emotional eating, hedonic eating, and binge eating than subjects who do not meet criteria for FA (non-FA).
- Weight loss induced by laparoscopic adjustable gastric banding or gastric bypass surgery is associated with reduced food cravings and reduced emotional and external eating behavior.

What this study adds

- Bariatric surgery-induced weight loss is associated with remission of FA in extreme obesity. FA was identified in 32% of subjects before surgery but only in 2% of subjects after surgery-induced weight loss.
- Bariatric surgery-induced weight loss is associated with decreased food cravings and emotional and external eating behaviors in both FA and non-FA subjects. However, restrictive eating behavior increases in FA subjects and does not change in non-FA subjects after surgery.

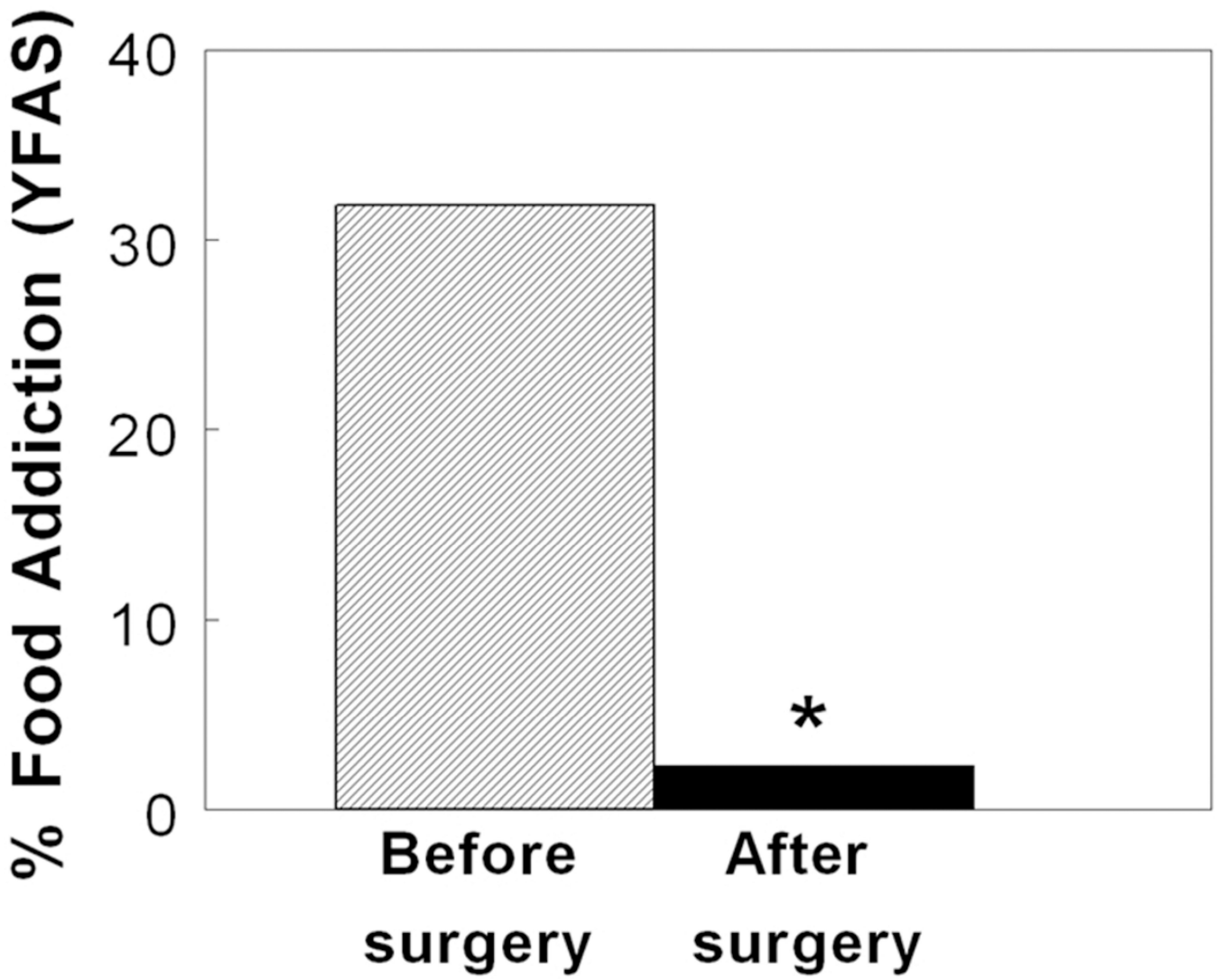

Figure 1.

Prevalence of food addiction measured by the Yale Food Addiction Scale (YFAS) in 44 obese patients before bariatric surgery and after ~20% surgery-induced weight loss. * Significantly different from before surgery, $P<0.05$.

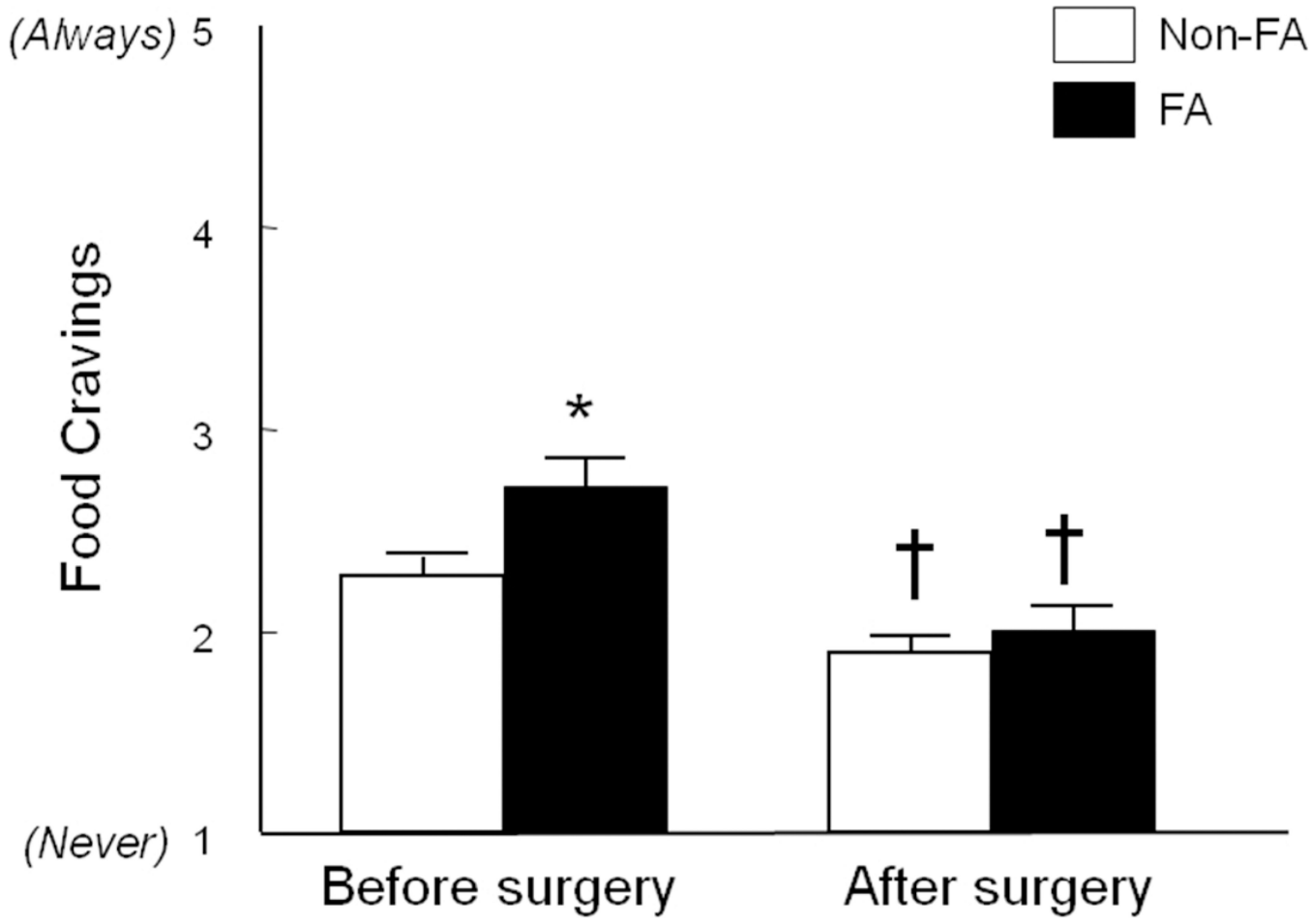

Figure 2.

Frequency of general food cravings before and after ~20% bariatric surgically induced weight loss in subjects who met criteria for food addiction (FA; black bars), and subjects who did not meet criteria for food addiction (non-FA; white bars). Data are presented as Mean (±SEM). * Significantly different from non-FA, P<0.05; ₸ Significantly different from before surgery, P<0.05.

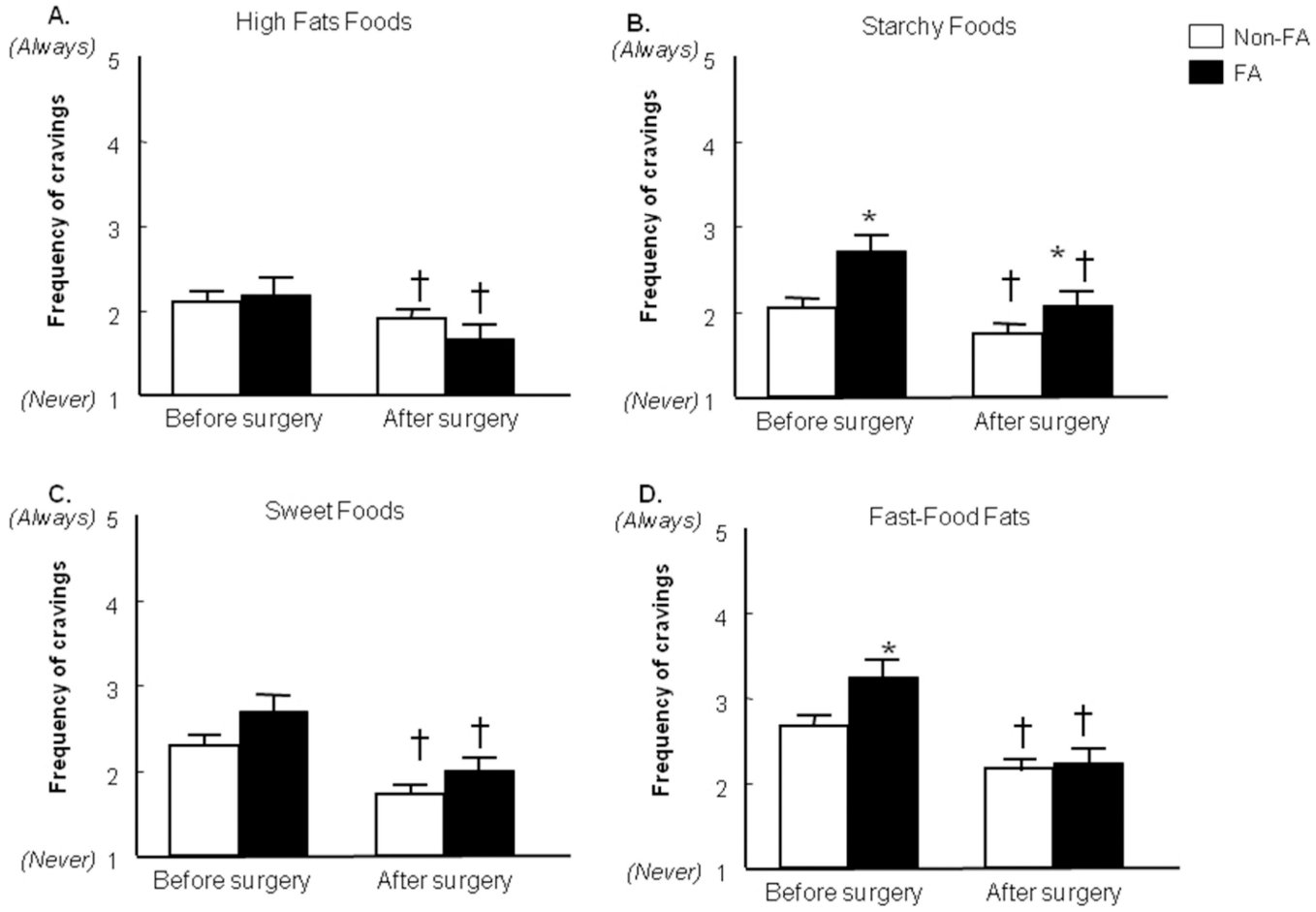

Figure 3.

Frequency of cravings for high fat foods (A), starchy foods (B), sweet foods (C), and fast-food fats (D) before and after ~20% bariatric surgically induced weight loss in subjects who met criteria for food addiction (FA; black bars), and subjects who did not meet criteria for food addiction (non-FA; white bars). Data are presented as Mean (±SEM). * Significantly different from non-FA, $P<0.05$; ∓ Significantly different from before surgery, $P<0.05$.

Figure 4.

Restrictive, emotional and external scores as measured by the Dutch Eating Behavior Questionnaire compared to the Dutch Normative Scores before and after ~20% bariatric surgically induced weight loss in subjects who met criteria for food addiction (FA; black bars), and subjects who did not meet criteria for food addiction (non-FA; white bars). Data are presented as Mean (±SEM). * Significantly different from non-FA, $P<0.05$; ₸ Significantly different from before surgery, $P<0.05$. Dutch normative scores for obese women: 2.97 for restrained eating, 2.31 for emotional eating and 2.69 for external eating behavior. Dutch normative scores for obese men: 2.35 for restrained eating, 1.90 for emotional eating and 2.73 for external eating.

Table 1

Subject characteristics

	Non-FA (n=30)	FA (n=14)	P value
Age (years)	42.6 ± 10.9	43.2 ± 11.1	0.87
Body weight			
Before surgery (kg)	132.6 ± 24.3	131.2 ± 28.3	0.87
After surgery (kg)	106.0 ± 21.4	103.9 ± 21.9	0.77
Weight loss (%)	20.2 ±2.7	20.7 ± 2.0	0.58
BMI (kg/m^2)			
Before surgery	48.2 ± 8.2	47.5 ± 8.0	0.81
After surgery	38.5 ± 6.9	37.7 ± 6.6	0.71
Type of surgery			
RYGB (%)	63	43	
SG (%)	17	21	0.42
LAGB (%)	20	36	
Race (%)			
White	77	86	
Black	20	7	0.47
Other/mixed	3	7	
Yearly income (%of group)			
<$35,000	30	7	
$35,000 – 75,000	37	57	0.17
>$75,000	33	36	
Years of education	14.3 ± 2.0	14.4 ± 1.7	0.57

Values are means ± SD.