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RESEARCH

Food Addiction 5 and 10 Years Following Metabolic and Bariatric Surgery: a Prospective Observational Study

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Abstract

Background Food addiction (FA) is prevalent among individuals undergoing metabolic and bariatric surgery (MBS), but few studies have investigated the prevalence and correlates of post-surgical FA over longer periods. We report an observational, longitudinal study investigating prevalence of post-surgical FA at 5 and 10 years following MBS.

Methods Participants in the Oslo Bariatric Surgery Study (OBSS) completed the modified Yale Food Addiction Scale 2.0 (mYFAS) and measures of psychological functioning and weight outcomes (% total weight loss: %TWL and % weight recurrence: %WR) at 5 and 10 years follow-up.

Results $N = 173$ of 224 (23% lost-to-follow-up) participants (73% women, 93.6% Roux-en-Y gastric bypass) completed the mYFAS 2.0 at 5 years and 10 years following MBS. The prevalence of FA was 12.9% at 5 years and 8.4% at 10 years after MBS. A higher number of FA symptoms at 5 years significantly predicted less %TWL and lower psychological functioning at 10 years. At 10 years, the majority of individuals with FA had moderate or severe symptoms and 3% were new-onset cases of FA. Higher FA at 10 years was concurrently associated with less %TWL, greater %WR, and lower psychological functioning at the 10-year follow-up (p's < 0.001).

Conclusions The prevalence of FA decreased from 12.9 to 8.4% between 5 and 10 years following MBS. We observed prospective and concurrent associations between FA symptoms and poorer weight loss and mental health outcomes. The presence of post-operative FA may be an important target for continued assessment and follow-up care to improve longer-term outcomes.

Keywords Obesity · Metabolic and bariatric surgery · Food addiction · YFAS · Obesity treatment

Key Points
- Food addiction (FA) is prevalent among individuals undergoing MBS, but little is known regarding the long-term prevalence and correlates of post-surgical FA in the decade following surgery.
- Prevalence of FA was 12.9% at 5 years and 8.4% at 10 years following MBS based on the mYFAS 2.0.
- Post-surgical FA was prospectively and concurrently associated with poorer weight outcomes and mental health symptoms at 10 years following MBS.
- Findings underscore the importance of continued monitoring of FA over the long term following MBS.

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Introduction

While metabolic and bariatric surgery (MBS) is widely regarded as the most effective treatment of obesity [1, 2], it does not guarantee a satisfactory long-term outcome for all patients, and weight recurrence is common [3–5]. Disinhibited types of eating behavior such as food addiction (FA) are prevalent among individuals undergoing MBS [6–9] and linked to weight outcomes in the short and intermediate

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term [10, 11]. FA remains a controversial concept [12] often defined as the hedonic addictive-like consumption of highly palatable and processed foods and marked by psychological and behavioral symptoms such as cravings, altered tolerance, and withdrawal [13–15]. The Yale Food Addiction Scale 2.0 (YFAS; [16]) was developed to measure the proposed criteria for FA which are based on Diagnostic and Statistical Manual for Mental Disorders 5th edition criteria for substance-related and addictive disorders (DSM-5; [17]).

A recent meta-analysis estimated the pooled prevalence of FA as measured by the YFAS to be 32% prior to surgery (range: 6.3 to 69%) and 15% following surgery (range: 0 to 32%) [18]. The majority of reviewed studies are, however, limited by a cross-sectional design, examining FA either prior to ($n=26$) or after surgery ($n=7$), and the few longitudinal studies ($n=7$) ranged from 6 months to a maximum of 24 months follow-up [18]. Little is known regarding the prevalence of FA beyond 2–3 years following MBS. However, there is some indication from available longitudinal studies that rates decrease sharply following MBS but then rebound, as evidenced by lower rates of FA at 6–9 months (0 to 2.2%) [19, 20] than at 24 months following surgery (10–14.2%) [21, 22]. This suggests that although rates of FA decline to less than half of pre-surgical levels after surgery [18], it is unclear whether initial improvements are transient or endure over longer periods. After experiencing an initial reprieve from symptoms, many individuals may develop eating problems, or symptoms may reoccur. Evidence on related, but distinct forms of disordered eating behavior such as binge eating (BE) (see [23–25] for a review of conceptual and empirical distinctions) indicate considerable instability in symptom trajectory over time, marked by symptom remission, relapse, or new onset [10, 26, 27]. This underscores the importance of extending the evidence base beyond the 12–24-month timeframe to improve our understanding of the presence of post-surgical FA as time progresses.

Food addiction is strongly associated with obesity and lower psychological functioning, for example, greater depression and anxiety, among individuals seeking surgical treatment [28, 29]. However, FA is not consistently associated with pre-surgical BMI or weight, nor is it reliably associated with initial post-operative weight loss [6, 11, 30–32]. On the other hand, the presence of post-surgical FA has been associated with poorer concurrent mental health functioning, including higher levels of anxiety and depression, along with greater weight recurrence [33]. One study, for instance, found that individuals with post-surgical FA had less weight loss 12 months after sleeve gastrectomy [34]. This pattern of findings is consistent with related literature on eating behavior. Studies on non-normative eating behaviors indicate that such behaviors have minimal impact on outcomes when measured prospectively at baseline; however, when these behaviors are assessed concurrently, they are associated with attenuated weight loss up to 6 years following MBS [35].

An increasing number of studies have explored the prevalence and utility of assessing addictive-like eating behaviors and their impact on surgical outcomes. No prior study, however, has investigated post-surgical FA at 5 and 10 years following MBS. This is despite calls to extend our understanding of the relationships between post-surgical FA, associated features, and longer-term weight outcome [11, 18], as relationships may change over time following MBS. There is evidence to suggest that proximal, or concurrent, associations between non-normative eating behaviors and weight outcomes are stronger than prospective, or distal, associations [35], but our knowledge is limited to the predictive significance of pre-operative behavior. This study aimed to explore the prevalence of post-surgical FA at 5 and 10 years following MBS as measured by an abbreviated version of the YFAS (mYFAS 2.0; [36]. Additionally, we explored whether FA at 5 years was prospectively associated with psychological functioning and weight outcomes at 10 years, and whether FA at 10 years was concurrently associated with outcomes. To our knowledge, this study is the first investigation to assess the prevalence of FA a decade after MBS.

Method

Two hundred twenty-four individuals who received MBS at Oslo University Hospital between February 2011 and September 2013 participated in a 5- and 10-year follow-up assessment as part of a larger observational, prospective study of bariatric surgery [37, 38]. Inclusion criteria were a BMI ≥ 40 or a BMI ≥ 35 kg/m^2 with obesity-related comorbidity and age ≥ 18 years at the time of surgery. The final study sample consisted of 173 participants who participated in the 10-year assessment (173/224; 23% lost-to-follow-up). All participants provided written consent, and the study was approved by the Institutional Review Board at Oslo University Hospital and the Regional Committee for Medical and Health Research Ethics in Norway (2012/17028).

Measures

Demographic and Descriptive Information Type of surgery (Roux-en-Y gastric bypass or sleeve gastrectomy), re-operations for MBS, age, sex, education, employment status, and marital/cohabitation status.

Weight Variables Weight (kg) was measured using a platform scale (Seca 635, III; 0–300 kg) on the day of surgery with light clothing and at the 5-year follow-up consultation. Self-reported weight was used for the lowest post-operative

weight (nadir) and at 10 years (note: the correlation between self-reported and objectively measured weight at the 5-year follow-up was $r = 0.98$). Body mass index (BMI, kg/m^2), BMI change, percent total weight loss (%TWL) [i.e., 100 * (pre-surgery weight − post-surgery weight)/pre-surgery weight] and percent weight recurrence (%WR) [i.e., 100 * (post-nadir weight − nadir weight)/nadir weight] were calculated following standardized reporting guidelines [39].

Modified Yale Food Addiction Scale 2.0 (mYFAS) The mYFAS 2.0 [31] is a brief, 13-item version of the YFAS 2.0, assessing the frequency and severity of FA based on the DSM-5 criteria for substance abuse and dependence [16]. The mYFAS 2.0 has been validated in pre-surgical [40] and post-surgical [41] samples. The Norwegian version of the mYFAS was derived from a YFAS 2.0 translation [42]. Each item is scored on a Likert scale from "0" (never) to "7" (every day). In this study, the number of FA symptoms endorsed (e.g. tolerance, withdrawal, craving) was summed to calculate a symptom count (0–11). Additionally, FA was categorized as "absent": no FA (no clinical significance and/or 1 or less symptoms) or "present": mild FA (two or three symptoms plus clinical significance), moderate FA (four or five symptoms plus clinical significance), or severe FA (six or more symptoms plus clinical significance). Cronbach's alpha for the mYFAS 2.0 was 0.90 and 0.88 at the 5- and 10-year follow-up, respectively.

Psychological Functioning Psychological functioning was assessed using the Hospital Anxiety and Depression Scale [43]. The HADS is a 14-item self-report questionnaire measuring symptoms of anxiety (7 items) and depression (7 items). All items are rated on a 4-point Likert scale, and responses range from 3 ("yes, definitely") to 0 ("no, not at all"). The total and two subscale HADS scores were utilized to indicate the level of psychological functioning. Higher scores indicate greater symptomology. The Norwegian version of the HADS had acceptable to good internal consistency in the present study ($\alpha = 0.88$ for the total scale, $\alpha = 0.77$ for depression, and $\alpha = 0.84$ for the anxiety subscale).

Statistical Analysis

Statistical analyses were performed using R version 4.3.2 [44]. All available data at both 5 and 10 years were used without imputation. The prevalence of FA (absent = "no FA" or present = "mild, moderate, or severe") was calculated based on the scoring protocol for the mYFAS 2.0 [36]. Chi-square tests and *t* tests were used to compare individuals with and without FA at 5 years and at 10 years on demographic variables and outcome (%WR, %TWL, HADS).

Linear regressions were performed to test the relationship between FA symptom count (scoring range: 0–11) and weight and mental health outcomes at 10 years. In separate models, the FA symptom count at 5 years or 10 years was examined as a predictor of %WR, %TWL, or HADS score at 10 years. Sex, age, and surgery type were entered as covariates in all models, but were not significant for any outcome; therefore, we report uncorrected models without covariates. Significance level was set at $p < 0.01$.

Results

Patient Characteristics

Of the 173 participants, 73% were women with a baseline age of 44.8 years (± 9.3) and baseline mean BMI of 42.8 kg/m^2 (± 5.5) and had undergone RYGB (93.6% RYGB, 6% SG) (Table 1). At the 10-year follow-up, some 43% were in part- or full-time employment, 14% were retired, 35.8% were on (full or part-time) sick leave or disability benefits, and 5.8% were unemployed. Average %TWL from pre-operative weight to follow-up was 25.4% at 5 years and 23% at 10 years. The average percentage weight recurrence from nadir to 10 years was 34.9%. A substantial proportion had regained more than 25% WR at 5 years (41.6%) and at 10 years (38%).

Prevalence of FA and Symptom Scores at 5 and 10 Years Following MBS

The prevalence of FA at the 5-year follow-up was 12.9% ($n = 22$), and of these, 12 individuals (55%) were classified as moderate or severe FA and 10 (45%) were classified as mild (see Table 2). At 10 years, the prevalence of FA was 8.4% ($n = 14$), and of these, 10 (71%) were classified as having moderate or severe FA and 4 (29%) were classified as mild FA. In terms of trajectories; 139 individuals (80.3%) did not meet the proposed criteria for FA at either the 5-year or 10-year follow-up assessment; 9 (5.2%) had FA at both the 5-year and 10-year follow-up; 12 (6.9%) were considered "remitted," i.e., no longer classified as FA at 10 years; and 5 (2.8%) were "de novo" or new-onset cases of FA (i.e., no FA at 5 years but met criteria at 10 years). The mean mYFAS 2.0 symptom score for those with FA was 4.9 (± 2.5) at 5 years and 4.4 (± 1.9) at 10 years.

Concurrent and Prospective Associations Between FA and Outcome

At the 5-year follow-up, participants with FA at 5 years demonstrated significantly more symptoms of anxiety and depression (i.e., HADS at 5 years, $t(29.6 = -5.207$, $p < 0.001$, $d = -1.10)$. Further, those with FA at 5 years had a significantly higher %WR recurrence at 5 years (40.2% versus 23.9%; $t(25) = -3.024$, $p = 0.001$, $d = -0.712$) and

Table 1 Sample characteristics at baseline, 5 years, and 10 years following MBS

	Pre-operative *N* (%) or M (SD)	5 years post-op *N* (%) or M (SD)	10 years post-op *N* (%) or M (SD)
Sex			
Female	127 (73%)		
Male	46 (27%)		
Age	44.9 (9.3)	–	–
Surgery type			
Roux-en-Y gastric bypass	161 (93.6%)		
Sleeve gastrectomy	11 (6%)[a]		
Re-operation			5 (2.8%)
Have a partner/married	118 (69%)	128 (75%)	131 (76%)
BMI	42.8 (5.5)	32.7(6.3)	32.9 (6.5)
Change in BMI from pre-op	–	10.2 (5.1)	9.8 (5.3)
% weight loss (%TWL)		23.6(11.0)	23.0 (11.5)
% weight recurrence (%WR)	–	25.7 (23.5)	34.9 (26.7)
> 25% weight regain from nadir		57 (41.6%)	63 (38%)
HADS		10.2 (7.21	10.5 (6.9)

BMI body mass index kg/m^2, *HADS* Hospital Anxiety and Depression Scale, *%TWL* percent total weight loss, *%WR* percent weight recurrence

[a]$n = 1$ missing on surgery type variable

Table 2 Symptoms and prevalence of FA at 5 and 10 years following MBS measured by the modified Yale Food Addiction Scale 2.0 (mYFAS 2.0)

	5 years	10 years
FA category, *N* (%)		
No	148 (86%)	153 (88%)
Mild	10 (6%)	4 (2%)
Moderate	4 (2%)	7 (4%)
Severe	8 (5%)	3 (2%)
Total FA	22 (12.9%)[a]	14 (8.4%)[b]
Symptom count, total sample, *m* (sd)	1.1 (2.0)	0.7 (1.5)
Symptom count in FA group[c], *m* (sd)	4.9 (2.5)	4.4 (1.9)

[a]$n = 3$ missing on FA variable at 5 years

[b]$n = 6$ missing on FA variable at 10 years

[c]FA group = mild, moderate or severe. FA = food addiction (no FA = no clinical significance and/or 1 or less symptoms; mild FA = 2 or 3 symptoms and clinical significance; moderate FA = 4 or 5 symptoms and clinical significance; severe FA = 6 or more symptoms and clinical significance)

lower %TWL (16.1% vs 24.7%: $t(33) = 4.277$, $p < 0.001$, $d = 0.803$). At the 10-year follow-up, participants with FA at 10 years had significantly more symptoms of anxiety and depression ($t(12.9) = -3.214$, $p = 0.007$, $d = 0.94$) than those without FA. There was a trend for less %TWL at 10 years between FA and no FA groups (15.3% vs 23.8%, $p = 0.03$), but this did not reach significance.

As shown in Table 3, regression models showed that FA symptoms at 5 years significantly predicted %TWL and the HADS total score at 10 years (p's < 0.01). In the regression models of concurrent associations, FA symptoms at 10 years significantly predicted %WR, %TWL, and HADS total score at 10 years (all p's < 0.001). The adjusted R^2's were generally lower for the 5-year prospective effects than the 10-year concurrent effects. For instance, FA at 5 years accounted for 1.7% of the variance in %WR at 10 years (n.s.), whereas FA at 10 years accounted for 8.6% of the variance in %WR at 10 years ($p < 0.0001$; Table 3).

Discussion

Emerging research indicates that the prevalence of FA is notably high among individuals seeking MBS, yet the longer-term prevalence and associations of post-surgical FA beyond the initial 1 to 2 years after MBS remains unknown. This is the first study to investigate post-surgical FA at 5 and 10 years following MBS. The prevalence of individuals who met the proposed criteria for FA using the mYFAS 2.0 decreased from 12.9 to 8.4% between 5 and 10 years. The majority of FA cases at both timepoints were classified as moderate or severe FA. Post-surgical FA at 5 years and 10 years was significantly associated with less %TWL and lower psychological functioning at the 10-year mark. Additionally, the presence of post-surgical FA symptoms at 10 years significantly predicted %WR at 10 years. These findings suggest that post-surgical FA is a clinically relevant

Table 3 Regression models examining prospective (5 years) and concurrent (10 years) associations of post-surgical FA on %WR, %TWL, and psychological functioning at 10 years following MBS

	Coefficient, *B*	SE	*t* value	*p*	95% CI	Adjusted r^2
%WR at 10 years						
mYFAS at 5 yr	2.057	1.043	1.973	0.050	−0.00 to 4.126	0.017
mYFAS at 10 yr	5.538	1.370	4.041	*< 0.001**	2.83–8.24	0.086
%TWL at 10 years						
mYFAS at 5 yr	−1.348	0.443	−3.039	*0.003**	−2.22 to −0.47	0.048
mYFAS at 10 yr	−2.019	0.601	−3.362	*0.001**	−3.21 to −0.83	0.059
HADS total at 10 years						
mYFAS at 5 yr	0.821	0.266	3.088	*0.002**	0.30–1.34	0.049
mYFAS at 10 yr	1.690	0.355	4.755	*< 0.001**	0.99–2.39	0.115

FA food addiction, *HADS* Hospital Anxiety and Depression Scale, *mYFAS* modified Yale Food Addiction Scale 2.0, *%TWL* = % total weight loss, *%WR* % weight recurrence

*$p \leq .01$ level

behavior to assess, given its association with longer-term weight and mental health outcomes a decade following MBS.

Our 5-year and 10-year FA rates generally align with cross-sectional studies of post-surgical FA, where a meta-analysis estimated the pooled prevalence to be 15%, as well as the reviewed longitudinal studies, where the prevalence of FA decreased from 34 to 9% up to 24 months following MBS [18]. The current findings contribute to existing literature by showing that FA tends to improve during the post-operative period [20, 45] but then subsequently decreases to levels comparable to post-MBS surgery patients as well as the general population. In fact, the prevalence of post-surgical FA assessed with the mYFAS in our study (i.e., 12.9% and 8.4% at 5 and 10 years) aligns more closely with rates in representative general population samples in Italy (6%) [46], Brazil (3%) [46, 47], and the US (13–15%) [36, 48], than pre-surgical populations (20–50%) [15, 18]. This result is encouraging and suggests that post-surgical rates of FA decline to population levels in the decade following MBS. Also promising is that the majority of the sample, approximately 80%, never endorsed FA at either timepoint and 6.9% were classified as remitted, i.e., no longer classified as FA at the 10-year follow-up. Nonetheless, we found that 5.2% of the sample were classified as having FA at both timepoints, and approximately 3% of our sample were "de novo" cases that had developed FA between the 5- and 10-year follow-ups. This contrasts with findings from Pepino and colleagues [20] who reported no new cases at 6 months. Further, a majority of individuals who met the proposed criteria for FA were classified as having moderate or severe symptoms, not mild. While post-surgical FA at 5- and 10-years post-MBS was relatively uncommon, those affected experienced moderate to severe symptoms. This is a novel finding and suggests that despite the declining rate of FA across 10 years post-op, it is important to remain vigilant for post-surgical FA symptoms due to their potential severity and negative associations with outcome.

While studies of pre-operative FA in surgical populations have found little to no evidence linking pre-surgical FA to outcome following MBS [21, 28, 30, 31], a growing body of research, including ours, highlights the utility of continued monitoring of post-surgical FA during the post-operative period [7, 33, 49, 50]. We observed significant associations between post-surgical FA and %TWL and reduced psychological functioning, regardless of whether FA was measured prospectively at 5 years or measured concurrently at 10 years. Overall, however, the pattern of associations with %WR, %TWL, and psychological functioning tended to be stronger when FA was measured concurrently than prospectively. Post-operative FA at 10 years also significantly predicted %WR at 10 years. This adds some evidence to prior literature showing that non-normative eating behaviors tend to have more pronounced proximal effects than distal, prospective effects on outcome following MBS [35]. Nevertheless, our finding that FA at 5 years significantly predicted suboptimal weight loss at 10 years is distinct from longitudinal studies of pre-operative FA which have largely failed to show prognostic significance [11]. This is a novel finding and suggests the potential utility of assessing post-surgical FA to predict subsequent outcome after MBS. Future research is warranted to further explore this issue, yet our findings add nuance to a literature base that is otherwise characterized by shorter follow-up periods.

There are limitations to our study which are important to acknowledge. First, our assessment of FA was limited to 5 and 10 years post-surgery because the mYFAS 2.0 was not available at earlier timepoints. Second, although the mYFAS is a reliable proxy for the full-length measure, with high internal reliability and unidimensionality [36, 51], false negatives may occur. Our reliance on the mYFAS may have underestimated the FA symptoms or prevalence when compared to the full-length YFAS 2.0 [16] because the fewer items on the mYFAS effectively reduces the opportunity for an individual to score above the diagnostic threshold. A more comprehensive assessment of the interaction and

relative importance of related, but distinct, types of non-normative eating behaviors or diagnoses such as binge eating disorder, would be a natural extension of the current study. Third, only 6% of the patients underwent sleeve gastrectomy, the remaining Roux-en-y gastric bypass. Our findings on eating behavior may have limited generalizability for other types of surgery and should be carefully interpreted relative to outcome following sleeve gastrectomy. Lastly, data on ethnicity, gender identity, and sexual orientation were not available, but should be included in future studies of FA in MBS. Inclusion of minoritized groups is important within the study of disordered eating [52], and emerging evidence indicates there is an elevated risk of FA in marginalized populations [53] potentially related to increased exposure to multiple and intersecting sources of bias, including weight stigma [54].

In conclusion, the current study reported an overall prevalence of FA of 12.9% and 8.4% at 5 and 10 years, respectively, after MBS. At 10 years, the majority of individuals who met the proposed criteria for FA at post-surgery had moderate or severe symptoms, and 3% had developed de novo FA. Although the prevalence of FA was relatively low and comparable to general population estimates, FA was both prospectively and concurrently associated with weight outcomes and psychological functioning. Findings suggest the importance of continued monitoring of FA over the long-term following MBS.

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Author Contribution The overall OBSS study is managed by TM and coordinated by ILK. ILK and TM were involved in the data collection. DLR and SØL conceptualized the current study. SØL conducted the statistical analyses. SØL drafted the paper and DLR contributed to the writing process. All authors have made essential contributions to the paper structure, interpretation of the analyses, and revisions to the paper. All authors read and approved the final manuscript.

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Data Availability Only anonymous and aggregated data will be available upon request to protect the privacy of the participants.

Declarations

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Competing Interests The authors declare no competing interests.

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