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**Quasi-prospective, real-life monitoring of food craving post-bariatric surgery:
comparison with overweight and normal weight women**

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What is already known about this subject

- Food cravings are common experiences and identified as problematic for dieters and people with eating disorders.
- Food cravings have been implicated in post-bariatric dietary non-compliance and weight gain.
- There is limited research into post-bariatric food craving.

What this study adds

- A detailed characterization of post-bariatric food craving experiences, and in comparison with those of overweight dieters and normal weight non-dieters.
- Some assurance that, for most, cravings should be anticipated post-surgery, but no more frequently than in other obese individuals.
- That detailed accounts of potentially disruptive experiences like food cravings may help patients and clinicians plan for their management.

ABSTRACT

Food cravings are common post-bariatric surgery, suggested as predictors of relapse and weight regain, but relatively unstudied, especially in the longer-term. The present study investigated the frequency and nature of food craving experiences after gastric surgery in comparison with non-surgical control participants.

5 Participants were 21 women, 4 to 38 months post-surgery (mean age=44 years, 9 following gastric banding, 12 after Roux-en-Y gastric bypass), and two comparison samples of 39 overweight dieters and 33 normal weight non-dieters. They completed a food craving record after every food craving, a daily mood assessment, and a food diary over a 7-day period. Over the 299 craving episodes, savoury foods

10 were the most commonly craved (40% of craving events), followed by chocolate (31%). Post-bariatric patients reported more and stronger cravings than normal weight non-dieters but at a similar frequency and strength to overweight dieters. Neither hunger nor negative mood distinguished the food cravings of post-bariatric patients from those of comparison participants, nor did the proportion that led to

15 eating (58%). Food cravings should be anticipated post-bariatric surgery but no more so at a mean of 12 months post-surgery than by other overweight or obese individuals. Food cravings are not the product of extreme hunger nor do they have the connection with negative mood seen in disordered eating. In addition, the ability to fulfill cravings by eating the craved food is reduced by the surgery itself, although

20 the duration of surgical restraint is uncertain.

INTRODUCTION

Observations of variation in bariatric surgery weight loss and its maintenance
25 have generated interest in post-surgical eating behaviour and appetite control.
Maladaptive eating, either as excessively restricted eating or over-eating, has been
observed in up to a quarter of patients (1). Over-eating is manifest as binge eating
(real or perceived), stress or emotional eating, consumption of high fat and/or sugar
snacks, or grazing. Accordingly, this apparent dietary non-compliance is a possible
30 explanation for post-surgical weight regain, although whether this reflects a carry-
over of problematic pre-surgical behaviours is questionable (2,3).

Food cravings have been suggested as predictors of relapse and weight
regain (4). They are reported in up to half of post-bariatric patients (5) and likely
related to what is described as 'head hunger' in numerous individual and bariatric
35 support-group web-postings. However, only two studies have purposively
investigated food craving in bariatric patients. Crowley et al (6) related patient's pre-
surgery scores on the Food Craving Questionnaire-Trait (7) to weight loss 6 months
post surgery. High scores on 'guilt from cravings and/or giving in to them' were
significantly associated with less short-term weight loss. Leahey et al (8) used the
40 Food Cravings Inventory (9) to look at the number of food craving prior to, and at 3
and 6 months after surgery. They found that food cravings decreased post-surgery,
especially those for sweets and fast food, but not to normative levels (i.e. those of
normal weight controls). Interestingly, there were no differences in craving
frequency between restrictive and malabsorptive/restrictive surgeries.

45 Information on post-bariatric food craving is limited not only in research output
but also in characterization of experience. A variety of assessments have been
developed to measuring food craving (10). These range from the questionnaires and

inventories of commonly craved food referred to above, to more descriptive accounts based on interviews (11) or templated records of craving (12). The latter approaches
50 are directed at the phenomenology of food craving experience and allow their characterization in response to interventions and of participant groups. Of relevance here are the strong association found with negative mood but not hunger in women with bulimia nervosa (13), clear distinctions between food cravings and aversions during pregnancy and their relationship with nausea (14), and dieters' craving for
55 foods they were restricting eating (12).

There is a need for more information on post-bariatric food craving, especially in relation to the experiences themselves, and in comparison with other overweight individuals. In addition, this investigation should go beyond 6 months post-surgery given the time-course of changes in eating behaviour. Accordingly, this study
60 investigated the frequency and nature of food craving experiences in post-bariatric patients. It was hypothesized that post-bariatric patients would report more food craving experiences than non-bariatric participants. Particular attention was given to the role of negative mood and hunger in these experiences and whether cravings would be for foods they were trying to restrict or avoid eating. In addition, even
65 though Leahey et al (8) found no difference in frequency, the study examined possible differences in the food craving experiences of gastric band and gastric by-pass patients

METHODS

70 Participants

Twenty one women (mean age=43.8 years) who had received bariatric surgery were recruited from two sources: a local NHS bariatric follow-up clinic and

via a notice on a bariatric support website, available over a 4 week period (www.wlsinfo.org.uk - Weight Loss Surgery Information and Support). Aside from
75 having bariatric surgery the only entry requirement was that they were at least 3 months post-surgery. Of the 40 participants who registered interest in the study, one withdrew before questionnaires were sent out, 15 did not return their questionnaires, and 3 returned incomplete questionnaires. Of the final patient sample, 9 had received a laparoscopic adjustable gastric band (LAGB) and 12 Roux-en-Y gastric
80 bypass (RYGB). They were an average of 12.3 months post surgery (range 4 to 38 months) and were from bariatric surgery centres across the UK. Comparison participants were a sub-sample who had taken part in another study using the same assessments over an identical time period (12). This study investigated the relationship between dieting and food craving and recruited women from slimming
85 clubs and the community. Of the 129 women in this study, those currently dieting to lose weight and with a Body Mass Index (BMI)>25 were allocated to an overweight dieter comparison group (N=39), and those not dieting to lose weight and with a BMI<25 to a normal weight group (N=33).

The study was approved by the Leeds (East) NHS Research Ethics
90 Committee (ref. 07/Q1206/27).

Measures

Craving record. This was developed by Hill & Heaton-Brown (15) and used in previous investigations of food craving (12-14). The craving record is a
95 questionnaire that participants complete shortly after each craving experience. It requires the participant to note the time of the craving experience and to rate its main features. Questions are directed at four main areas: the antecedents to and context

of the craving (including whereabouts, social context, and triggers); craving intensity; the nature of the food craved and subsequent behaviour; and accompanying hunger and mood state. Participants rated their mood and hunger levels immediately before and after the craving occurred, providing onset and post-craving measures. Visual analogue scales (100mm) were used for participants to rate hunger and characteristics of the craving experience (strength, difficulty resisting, target food restriction, speed of disappearance), a procedure commonly used in assessment of hunger motivation (16). The mood state assessment was a shortened (12-item) version of the UWIST Mood Adjective Checklist (UMACL) (17). This has three subscales: hedonic tone (happy, sad), tense arousal (tense, relaxed), and energetic arousal (alert, tired).

Daily questionnaire. This was ten 100mm visual analogue scales (anchored not at all to extremely) completed towards the end of each study day. Participants were asked to rate each of the following states according to how they felt that day: anxious, ease of eating control, content, thirsty, hungry, tense, irritable, alert, vulnerable (emotionally), bored.

Food diary. Participants were asked to record what they ate and drank over the study period in a standard food diary, noting the time of consumption and the approximate quantity of food and drink consumed. The intention was to use the diary to describe eating episodes rather than to measure food intake and to locate food craving experiences within participant's eating patterns.

Background questionnaire. This included questions about current weight and height, weight history, weight prior to bariatric surgery, date and type of surgery, body shape perception and dietary restraint (18).

Procedure

125 A brief description of the study and the researcher contact details were made available to patients at a bariatric out-patients clinic and on the Weight Loss Surgery Information and Support website. Expressions of interest resulted in patients being sent, by email or post, a participant information sheet and consent form. On return of the signed consent form, participants were sent a study pack with instruction sheet, 20 craving record forms, 7 daily questionnaire forms, and a food intake diary.

130 Participants were then phoned and given instructions on how to complete the questionnaires. They were asked to complete a new craving record on each occasion they experienced a food craving and as soon after the craving as possible. To familiarize participants with the study materials, they were asked to complete a sample copy of the daily questionnaire according to how they had felt that day, to

135 record the day's food and fluid intake in the food diary, and to recall their most recent food craving using a food craving record. During this conversation, participants were asked about any current medical problems and medications that could have an effect on their appetite. For the purpose of this study a food craving was defined as a strong desire to eat a particular food regardless of whether they ate in response.

140 Participants were contacted by phone at approximately 5 days through the recording period to check for any difficulties in completing the assessments and to remind them to return the questionnaires in the provided pre-paid envelope.

Data analysis

145 Data were analysed using SPSS (Statistical Product and Service Solutions v.18.0 for Windows) and checked for normality and outliers. One-way and multivariate analysis of variance (MANOVA with age included as a covariate), with Student Neuman Keuls post-hoc tests, were used to compare bariatric patients, overweight

dieters and non-dieters. Chi-squared tests were applied to categorical data.
150 Correlational analysis (parametric and non-parametric) examined the relationship
between variables.

RESULTS

Participant characteristics are summarised in Table 1. Post bariatric patients and
155 overweight dieters were significantly heavier (current weight, $F(2,89)=44.06$, $p<.001$)
than normal weight controls. All three groups were significantly different in BMI
($F(2,89)=51.94$, $p<.001$), ideal weight ($F(2,90)=25.15$, $p<.001$), maximum past weight
($F(2,90)=100.70$, $p<.001$), and dietary restraint ($F(2,90)=27.64$, $p<.001$). RYGB
patients had a higher maximum past weight compared with LAGB patients
160 ($t(19)=3.06$, $p=.006$) and a greater post-surgical weight loss ($F(1,16)=5.23$, $p=.04$;
adjusting for time since surgery).

Foods craved

Overall, participants completed 299 craving records. The majority of cravings were
165 experienced at home (62%), in the company of others (52%), and in the afternoon
(36%) or evening (41%). The food cravings of post-bariatric patients occurred
significantly earlier in the day than those of overweight dieters ($F(2,287)=4.16$,
 $p=.02$), the average time of day being early afternoon and late afternoon
respectively. There was no difference between LAGB and RYGB patients.

170 Savoury foods were the most frequent target of cravings (39.6% of episodes),
followed by chocolate (31.4%) and sweet foods (20.8%). Savoury food cravings
included meal foods, bread, cheese, and snacks, while sweet food cravings were
most commonly for biscuits, cake, desserts and confectionery. There was no

association between participant group and craving target ($\chi^2(6)=9.80$, NS (not
175 significant)). However, separating the surgical groups did reveal an association
($\chi^2(9)=18.24$, $p=.03$). LAGB patients had a higher proportion of savoury food
cravings (65%) than RYGB patients (43%) or either of the comparison groups (33%
and 37%).

There was an association between participant group and time since last
180 eating episode (recorded in hourly blocks, $\chi^2(10)=47.6$, $p<.001$). Post-bariatric
patients experienced food cravings sooner after eating than participants in either
comparison group. For example, 59% of bariatric patient's cravings occurred within
2 hours of eating, compared with 35% of overweight dieter's cravings and 38% of
normal weight participant's cravings. Conversely, 24% of bariatric patient's cravings
185 occurred 6 or more hours after last eating, compared with 11% of overweight dieter's
cravings and 6% of normal weight participant's cravings. While this pattern of
relationship with prior eating was most pronounced in RYGB patients there was no
significant difference between surgical groups.

190 Craving frequency and characteristics

There was a significant group difference in the number of food cravings over the 7-
days of recording ($F(2,90)=3.27$, $p=0.04$), with post-bariatric patients reporting more
than normal weight controls and overweight dieters intermediate (Table 2). Some 19
of 21 post-bariatric patients (90%) experienced and recorded a food craving in this
195 period compared with 36 of 39 overweight dieters (92%), and 23 of 33 normal weight
controls (70%).

In the post-bariatric patient group there was no significant correlation between
craving frequency and time since surgery ($r(21)=0.38$, NS), current BMI, age,

restraint, or weight loss following surgery (all <0.29 , NS). However, across the full
200 sample of participants there was a significant positive correlation between craving
frequency and dietary restraint ($r(93)=0.32$, $p=.002$), but not with BMI or age (0.19
and 0.06 respectively, NS). BMI and dietary restraint were also positively inter-
correlated (0.49 , $p<.001$).

Table 2 summarizes features of the craving experience together with rated
205 hunger and mood immediately before and after the craving. MANOVA on the pre-
craving ratings revealed a main effect of participant group ($F(14,558)=9.13$, $p<.001$).
Univariate tests showed significant group differences in craving strength, resistibility,
and target food restriction, but no difference in hunger or mood. Compared with
normal weight controls, post-bariatric patients had significantly stronger cravings for
210 foods that they were moderately restricting eating. Compared with overweight
dieters, post-bariatric patients had similar strength cravings for foods which they had
significantly less difficulty resisting and for foods they were not restricting eating as
much as dieters. There was no difference between surgical groups on any of these
pre-craving measures.

215 The majority of cravings were fulfilled by eating the craved food (58%), a
proportion that did not differ by participant group ($\chi^2(4)=5.18$, NS). Eating a different
food to that craved was reported on 15% of occasions and not eating on 27%.
Estimates of the time that the craving was resisted were marginally different between
groups ($F(2,205)=3.02$, $p=.05$), with post-bariatric patients delaying eating for 33.4
220 (standard error=9.7) minutes and non-dieters by 14.1 (3.6) minutes. There was no
significant association between the type of food craved and eating or resisting the
craving ($\chi^2(6)=9.72$, NS).

The post-craving ratings also showed a significant group effect (F(10,556)=4.36, p<.001). Univariate tests were significant for all three mood components (Table 2). Post-bariatric patients rated their post-craving mood as lower in hedonic tone and energy, and higher in tension than that in the comparison groups. This decrease in hedonic tone was the only significant change in mood across the craving experience. Hunger decreased pre- to post-craving in all groups. Resisting a craving (by not eating) had no different affective consequences compared with eating following a craving in either the overweight or post-bariatric groups.

Daily mood

MANOVA showed that end of day ratings of mood differed according to whether a craving took place (F(10,490)=2.91, p=.002) and by group (F(20,980)=6.21, p<.001) but there was no craving by group interaction. On craving days participants were significantly more anxious, tense, irritable, emotionally vulnerable, hungry, had less control over eating, and were less content than they rated themselves on non-craving days. Post-bariatric patients were significantly less hungry and content than both comparison groups, and shared with overweight dieters less ease in eating control compared with normal weight comparison participants.

End of day mood also distinguished the surgical groups (F(10,118)=3.49, p<.001), with univariate tests significant for ratings of tension, irritability, and emotional vulnerability (F(1,127)= 17.80, p<.001; 10.46, p=.002; and 5.17, p=.025, respectively). RYGB patients scored consistently higher on these measures of negative mood than LAGB patients.

DISCUSSION

The present study is one of very few that has intentionally and prospectively
250 examined food craving post-bariatric surgery. The main findings were as follows.
First, post-bariatric patients reported more food cravings than normal weight non-
dieters but at a similar frequency to overweight dieters. Cravings were reported
slightly more frequently than one every 2 days and so consistent with the past month
craving frequency of 'sometimes' in Leahey et al's patients (8). In both studies this
255 frequency of cravings was higher than that in normal weight controls. In this sample
of patients food craving frequency was not significantly related to time since surgery,
post-surgical weight loss, or current BMI.

Second, certain food craving features distinguished post-bariatric patients
from other participants, showing the value of including two comparison groups that
260 differed in weight status and dieting motivation. Compared with normal weight
controls, post-bariatric patients had stronger cravings for foods that they were
moderately restricting eating. Compared with overweight dieters, post-bariatric
patients had similar strength cravings for foods which they had significantly less
difficulty resisting and for foods they were not restricting eating as much.

265 These results also suggest important differences in the way that eating
restrictions are interpreted and acted upon by different groups of people. For
example, some studies of dieters or restrained eaters have observed more cravings
for foods participants reported self-imposed restriction over (12,19). In contrast,
long-term (2-year) adherence to a low-fat or low-carbohydrate diet resulted in
270 decreased cravings for the specific types of foods that were targeted for restriction
(20). This difference in outcome may be the result of recent, sustained success in
resisting cravings and not eating that characterised this adherence, and which

contrasts starkly with the on-off experience typical of many dieters or restrained eaters. Alternatively, it may reflect the external imposition of restriction.

275 Post-bariatric patients also have externally imposed reasons for resisting eating certain foods. These relate to the restricted gastric capacity or unpleasant post-ingestive consequences such as vomiting or dumping. Patient's strong and frequent food cravings therefore are less difficult to resist and less associated with purposive food restriction than those of other overweight people because of the surgery. This interpretation is in accord with that of bariatric surgery paradoxically increasing patient's internalised feelings of control, at least around 12 months following surgery (21,22). It describes being forced to make careful choices about what and how much to eat and the changes in eating and relationship with food post-surgery. Cravings do occur but because eating the craved foods post-surgery leads to unpleasant physiological consequences this is not viewed as self-restriction and so they are easier to resist. This does not necessarily imply that the cravings are less intense but that post-ingestive consequences provide an additional motivating factor for resisting the craving.

290 Third, pre-craving mood was not different between groups but post-bariatric patients had lower mood after craving. In contrast to patients with bulimia (13), negative mood was not a distinctive context for cravings for post-bariatric patients. Nor was hunger, either pre- or post-craving, an experience that distinguished the present study groups. Indeed, hunger was rated as relatively low pre-craving (below the scale mid-point), indicating that cravings did not emerge from episodes of extreme hunger. This is concordant with the observation that some 60% of post-bariatric patient's cravings occurred within 2 hours of eating. The daily ratings made at the end of each day further emphasise this disconnect with hunger. While hunger

was significantly higher on craving days (vs. non-craving days) across all participants, hunger ratings were lower in the post-bariatric group on all occasions.

300 Fourth, compared to RYGB patients, those with a gastric band had a higher proportion of cravings for savory foods and reported better daily mood (less tension or irritability). This pattern of savoury cravings contrasts with that of dieters and women with bulimia nervosa who report proportionately more sweet food cravings (12,13). These differences could reflect the different physiological consequences of
305 restrictive and malabsorptive/restrictive surgeries. They may also reflect pre-surgical food habits and preferences. It is notable that they were the only differences noted between the surgical groups and, although statistically significant, were modest in nature. Furthermore, this failure to find major frequency or characterization differences is consistent with the research by Leahey et al (8).

310 This study has several strengths. We used an established and comprehensive methodology for continuous 7-day recording of craving experiences proximal to their occurrence. We describe the procedure as quasi-prospective since while the monitoring for food craving incidents is prospective, their detailed account is retrospective, only being documented once the experience has passed. It is
315 notable that the present analysis is based on nearly 300 food craving experiences. The availability of two comparison samples enabled contrast with both overweight and normal weight individuals. In addition, the time post-surgery was longer than in previous studies. Regarding weaknesses, the bariatric sample was relatively small and self-selected in nature. Consequently, the study had low statistical power to
320 detect differences between groups and especially between the surgical subgroups. Depression and disordered eating were possible between group confounders and generalizability is questionable beyond this small female sample. In addition, the

study was cross-sectional rather than longitudinal in design. Given that previous research examined food cravings up to 6 months post-surgery (8), and the present group of patients were a mean of 12 month post-surgery, there is scope for further investigation over longer post-surgical periods as eating behaviour changes. There is clear opportunity to address these weaknesses in working with new bariatric cohorts or registries. This may assist in better understanding the biological mechanisms that underpin craving experiences and distinguish surgery types (23).

In terms of the practical value of this research, food cravings should be anticipated post-bariatric surgery but, in the main, no more so than by other overweight or obese individuals. Cravings were not associated with extreme hunger, nor the negative mood seen in bulimia nervosa. Indeed, the ability to fulfill cravings by eating the craved food is reduced by the surgery itself, even if there is uncertainty over the duration of these externally-imposed restraints. These assurances should be communicated to bariatric patients with the caveat that the present observations are derived from a group of patients who have been relatively successful in weight loss at 12 months post-surgery. For those who do have strong and frequent cravings post-surgery then the detailed account of experience reported here is congruent with acceptance-based or mindfulness approaches to eating that are suggested as helpful in coping with craving (24) and recommended for bariatric patients (25).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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Table 1. Participant characteristics (mean±standard error)

	LAGB (N = 9)	RYGB (N = 12)	All post- bariatric patients (N = 21)	Overweight dieters (N = 39)	Normal weight (N = 33)
Age (years)	40.1 (3.9)	46.6 (2.4)	43.8 (2.2)	41.1 (1.7)	36.7 (2.0)
BMI (kg/m²)	32.1 (2.7)	35.0 (1.4)	33.7 ^a (1.4)	31.0 ^b (0.8)	22.1 ^c (0.4)
Current weight (kg)	83.6 (6.1)	94.3 (4.6)	89.5 ^a (3.8)	83.9 ^a (2.3)	59.6 ^b (1.3)
Ideal¹ weight (kg)	67.9 (3.2)	74.7 (2.0)	71.8 ^a (1.9)	65.9 ^b (1.6)	56.1 ^c (1.0)
Max. ever weight (kg)	116.7 (6.2)	143.6 ² (6.0)	132.0 ^a (5.2)	94.3 ^b (3.1)	62.6 ^c (1.4)
Time since surgery (months)	12.2 (2.4)	12.4 (2.8)	12.3 (1.8)		
Weight loss since surgery (kg)	30.9 (4.1)	41.7 ¹ (4.6)	36.8 (3.3)		
Dietary restraint	3.2 (.3)	2.9 (.3)	3.1 ^a (.2)	3.5 ^b (.1)	2.2 ^c (.1)

¹ Self-defined by participants

420 ² Significant difference between surgical groups (p<0.05)

Means with different letter superscripts are significantly different to each other (p<0.05).

Table 2. Craving characteristics, hunger and mood (mean±standard error)

	LAGB (N = 9)	RYGB (N = 12)	All post- bariatric patients (N = 21)	Overweight dieters (N = 39)	Normal weight (N = 33)
Number of cravings (Range)	3.9 (0.7) (0-7)	4.3 (1.2) (0-15)	4.1 ^a (0.7) (0-15)	3.6 ^{ab} (0.5) (0-11)	2.3 ^b (0.5) (0-11)
Pre-craving					
Craving strength	70.2 (3.7)	67.0 (3.4)	68.6 ^a (2.7)	70.0 ^a (2.1)	58.7 ^b (2.9)
Difficulty in resisting	63.3 (5.9)	57.1 (4.8)	60.3 ^a (3.3)	71.2 ^b (2.6)	54.4 ^a (3.5)
Target food restriction	41.1 (6.2)	49.4 (5.0)	45.4 ^a (3.5)	70.9 ^b (2.7)	24.0 ^c (3.7)
Hunger	37.8 (5.3)	37.8 (4.7)	37.8 (3.6)	35.2 (2.8)	48.1 (3.8)
Hedonic tone	8.1 (.5)	7.4 (.5)	7.7 (.3)	7.9 (.3)	8.2 (.3)
Tense arousal	4.5 (.6)	4.5 (.5)	4.5 (.3)	3.8 (.3)	3.8 (.4)
Energetic arousal	6.6 (.6)	5.9 (.5)	6.2 (.3)	6.5 (.3)	6.0 (.4)
Post-craving					
Speed of disappearance	58.0 (4.5)	60.4 (4.4)	60.0 (3.4)	55.9 (2.6)	65.9 (3.6)
Pleasantness of food	67.7 (4.4)	71.6 (4.2)	69.9 (3.1)	78.9 (2.3)	74.4 (3.2)
Hunger	31.6 (5.1)	28.0 (4.3)	30.4 (3.2)	31.1 (2.5)	29.6 (3.4)
Hedonic tone	6.2 (.6)	6.7 (.6)	6.4 ^a (.4)	7.2 ^a (.3)	8.7 ^b (.4)
Tense arousal	5.4 (.5)	4.8 (.5)	5.1 ^a (.3)	3.8 ^b (.2)	3.2 ^b (.3)
Energetic arousal	5.7 (.6)	6.0 (.5)	5.8 ^a (.3)	6.9 ^b (.3)	6.0 ^{ab} (.3)

Means with different superscripts are significantly different to each other (p<0.05)