Weight loss in adults following bariatric surgery, a systematic review of preoperative behavioural predictors

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Summary
Bariatric surgery is effective in treating obesity in many cases, yet as many as 50% of patients may not achieve the desired weight reduction. Preoperative modifiable behavioural factors could help patient selection and intervention design to improve outcomes. Medline, EMBASE, Cochrane Library and PsychINFO were searched to identify studies published between 1 January 2008 and 14 February 2019 reporting on preoperative modifiable behavioural factors associated with postoperative weight loss, with minimum 2 years follow-up. A total of 6888 articles were screened, 34 met the inclusion criteria. Maladaptive eating behaviours (MEB), preoperative weight loss (PWL), and tobacco use were reported 21, 18, and 3 times respectively. Physical activity and substance abuse were each reported once. Positive associations were reported in 22.2% and 14.3% of articles for PWL and MEB respectively. Negative associations were reported in 5.6% and 33.3% of articles for PWL and MEB, respectively. Marked heterogeneity in outcome reporting hindered quantitative synthesis. The current paucity of evidence amenable to synthesis leads to ongoing uncertainty regarding the size and direction of association between PWL and MEB with outcomes following bariatric surgery. Long-term studies with common reporting of outcomes are needed.

KEYWORDS
bariatric surgery, behavioural predictors, modifiable predictors, preoperative predictors, weight loss surgery

1 | INTRODUCTION

Bariatric surgery rates have increased following the global rise in patients with obesity, as well as the recent advances in laparoscopic techniques.8 Evidence supports the efficacy of bariatric surgery to produce safe large-scale weight loss,2,9 yet outcomes are not always favourable. Reports range from 10% to 50% of patients not achieving the desired weight loss following surgery.1,5 This results in a re-emergence of medical and psychological comorbidities and a decrease in quality of life.6,7

Identifying predictors of postoperative outcomes has proven difficult.8 Many predictors have been proposed and investigated including preoperative body mass index (BMI), age, gender, preoperative weight loss, eating behaviours, history of psychiatric disorders and history of sexual abuse.8 Not all predictors share the same implications for patients. Most factors are not modifiable and can act as barriers to accessing treatment. As such, increasing emphasis is now being placed on identifying modifiable preoperative predictors.9 A subset of these are behavioural factors such as preoperative weight loss, eating behaviours, physical activity, tobacco use and substance abuse.8,10-13
Findings in this area could subsequently be used to formulate interventions similar to prehabilitation programmes used in multiple other disciplines of surgery.14

Previous reviews in this area have investigated the association of both modifiable and non-modifiable factors with postoperative weight loss. A systematic review of 15 studies by Livhits et al in 2009 found a positive association between preoperative weight loss and greater weight loss postoperatively.13 A further review of 115 studies by Livhits et al in 2012 also found a negative association between preoperative BMI and postoperative weight, while failing to find any association between eating behaviours and postoperative weight loss.9 However, the results were largely based on evidence from short-term weight loss outcomes. In the 2009 review, only 3 of 15 sources had follow-up periods of over 2 years, the rest ranged from 3 to 12 months. In the 2012 review, 53 of 115 articles had follow-up periods of over 2 years. This was less in the articles reporting on modifiable factors where only 13 out of 53 sources had follow-up periods greater than 2 years.

Minimum follow-up intervals are important in evaluating the results of bariatric surgery. Most patients will experience substantial weight loss in the first few months following surgery.15,16 This trend tends to stop with a plateau of weight loss seen during the first and second year postoperatively.17-19 A 2-year interval after surgery has been proposed as the minimum amount of time before reliably evaluating postoperative weight loss outcomes.20

The aim of this review is to identify and investigate the modifiable preoperative behavioural factors associated with postoperative weight loss at least 2 years postoperatively in adult patients with obesity undergoing bariatric surgery.

## METHODS

A systematic review of the literature published between 1 January 2008 and 14 February 2019 was conducted using searches of Medline, EMBASE, Cochrane library and PsychINFO. The searches were carried out between January and February 2019. Separate search strategies were developed for each database (Appendix A). Our inclusion criteria encompassed studies reporting on modifiable preoperative behavioural predictive factors of adults with obesity undergoing bariatric surgery. If a study included adults as well as patients <18 years of age, these were also included. We excluded studies published prior to 2008, not published in English, or with a post-operative follow-up of less than 24 months. Case series and case reports were also excluded.

Two independent reviewers performed the screening. Full text articles were retrieved for all screened results. Conference abstracts were accepted only if they reported sufficient data required for extraction. Review articles were not included, but their references were manually searched to identify other studies that met our inclusion criteria. Data regarding type of publication, study and predictive factor characteristics were collected. Predictors included were ones deemed to be modifiable behaviours that could be addressed preoperatively via behavioural interventions. When there was missing data regarding postoperative weight loss, corresponding authors were emailed with requests for that information.

Due to significant heterogeneity in the types of eating behaviours reported and the tools used to measure them, eating behaviours were grouped to allow comparisons to be made. When available, the specific eating behaviours and assessment methods were collected and stated. We compared these in terms of their effect on postoperative weight loss.

Each predictor was outlined according to their associative direction (positive, negative and neutral) and level of statistical significance. This methodology was selected in line with similar past reviews by Livhits et al10,12 who faced comparable difficulties in analysing studies with considerable variability in predictor and outcome reporting. Assessment of study quality was performed using the Newcastle-Ottawa Quality Assessment Tool (NOQAT), see Appendix B for marking criteria. An overall quality assessment was made on the basis of the available criteria to be evaluated. If all were of acceptable quality, the article was deemed of good overall quality. If only one criterion was of low quality, then the study was deemed of fair quality. If more than two criteria were of low quality, then the study was deemed of poor quality.

The protocol for this systematic review was prospectively registered with PROSPERO (CRD42019119358)21 and reported according to PRISMA guidelines.22 Ethical approval was not required.
3 | RESULTS

A total of 6888 initial records were identified following removal of duplicates. After abstract screening and full text review, 34 studies were included in the final review (Figure 1). Using the NOQAT, the majority of the included studies were found to be of poor quality (Table S1). There were insufficient studies using comparable preoperative and outcome variables of adequate quality to be combined in a meta-analysis.

The most common procedure reported was Roux-en-Y Gastric Bypass (RYGB) (n = 24), followed by laparoscopic adjustable gastric banding (LAGB) (n = 13), laparoscopic sleeve gastrectomy (LSG) (n = 11), biliopancreatic diversion and duodenal switch (BPD&DS) (n = 3) and vertical banded gastroplasty (VBG) (n = 3). The lowest average preoperative BMI was 42 kg/m² and the majority of cohorts had an average preoperative BMI between 42 and 50 kg/m². Most cohorts reported an average patient age between 40 and 50 years. Follow-up time ranged between 24 and 81 months. Most studies had a majority of female patients, ranging from 65% to 75% of the sample. This was not the case in two cohorts with veteran soldiers where there was a majority of male patients. Table 1 summarizes the characteristics of the included studies.

Five factors were reported a total of 44 times within the 34 articles. They were preoperative weight loss, eating behaviours, tobacco use, physical activity and substance abuse. Eating behaviours and preoperative weight loss were reported 21 and 18 times, respectively. The rest of the reported factors were in the minority with three reports for tobacco use, one for physical activity and one for substance abuse.

3.1 | Preoperative weight loss

Eighteen studies reported on associations of preoperative weight loss on postoperative weight loss. Thirteen articles found no association.23-35
| Author (year) | Study design | Operation(s) | Weight loss predictor/s reported | Predictive value | Patients | Mean age (SD) | % Female | Base BMI (kg/m²) | F/U (mo) | Mean post-op BMI (kg/m²) | Mean weight loss (SD) | Weight measurement method |
|---------------|--------------|--------------|---------------------------------|-----------------|----------|---------------|----------|-----------------|--------|----------------------|----------------------|--------------------------|
| Adams11 (2012)a | Retrospective cohort | LAGB, RYGB | 1. Tobacco Use 2. Substance Abuse | 1 to 2. Not predictor | 61 | 48.33 (7.3) | 33 | 45.47 (SD: 5.89) | 24 | 34.74 (SD: 8.19) | ∆BMI 11.2 | In clinic |
| Agüera49 (2015) | Prospective cohort | RYGB, LSG, VBG, BPD&DS | EB; Unspecified (EDI-II) | Not predictor | 139 | 40.6 (10.3) | 77.7 | 46.3 (SD: 6.4) | 24 | NR | NR | In clinic |
| Alger-Mayer38 (2008) | Prospective cohort | RYGB | Preop WL | Positive | 29 | 54.5 (8.9) | 80 | 52.2 (SD: 9.8) | 36 | 35.4 (SD: 8.2) | @ 36 mo | %TBLW 21.9 (117.7) %EWL 55.1 (20.2) @ 48 mo %TBLW 29.4% (115) %EWL 58.0 (19%) |
| Alger-Mayer38 (2009)b | Prospective cohort | RYGB, EB; BE (BES) | Not predictor | 157 | 45 (10) | 86 | 50.7 (SD: 8.0) | 24 | NR | %TBWL 34.3 (9.1) %EWL 64 (1.8) | | In clinic |
| Andersen31 (2014) | Prospective cohort | LSG | 1. Tobacco use 2. Preop WL | 1. Negative 2. Not predictor | 160 | 40.4 (11.1) | 73.1 | 46.8 (SD: 6.9) | 24 | 30.2 (SD: 5.7) | %EBMIL 78.3 (23.5) | In clinic |
| Becouarn32 (2010) | Retrospective cohort | LAGB | Preop WL | Not predictor | 97 | 40.9 (10.1) | 41.2 (SD: 10.7) | NR | 45.6 (SD: 6.8) | NR | %EWL 48.8 (25.9) | %EWL 68.9 (20.4) |
| Blackledge30 (2016) | Retrospective cohort | RYGB | Preop WL | Not predictor | 30 | 53.4 (10.9) | 47.9 (SD: 11.0) | NR | 47.3 (SD: 21.8) | NR | Overall NR, subgroup results in Table 4 |
| Brown34 (2013) | Prospective cohort | LAGB | Preop WL | Not predictor | 114 | 43.6 (12.4) | 80.2 | 43.4 (SD: 6.4) | 24 | NR | %EWL 49 | In clinic, by staff |
| Conceição46 (2017) | Prospective cohort | LAGB | EB; LOC, Picking and/or nibbling (EDE-Q) | Not predictor | 44 | 44.66 (9.92) | 85.2 | 44.95 (SD: 6.8) | 25.57 (SD: 3.57) | 35.16 (SD: 6.88) | %TWL 21.8 (9.44) %EBMIL 51.97 (25.23) %EWL 46.08 (21.81) | %TBLW 36.36 (7.51) %EBMIL 78.58 (18.66) %EWL 70.95 (15.77) | In clinic |
| Gerber37 (2016) | Prospective cohort | RYGB | Preop WL | Not Predictor | 121 | 48.2 (12.7) | 83 | 49.2 (R:35.2-71.6) | 24 | NR | %EWL 38 (26) | %EWL 51 (30) | %EWL 42 (25) |
| Goldenbluger40 (2017) | Retrospective cohort | LSG | Preop PA | Positive | 178 | 39.9 (11.2) | 68 | 42.9 (SD: 4.3) | 36 | 28.4 (IQR: 25.4-31.6) | %TWL 30.31 (9.9) %TBLW 70.32 (23.92) | Self-reported |
| Author (year)          | Study design       | Operation(s)   | Weight loss predictor(s) reported | Predictive value Patients | Mean age (SD) | % Female | Base BMI (kg/m²) | F/U (mo) | Mean post-op BMI (kg/m²) | Mean weight loss (SD) | Weight measurement method | Weight measurement method |
|-----------------------|--------------------|----------------|----------------------------------|---------------------------|---------------|----------|-----------------|----------|------------------------|----------------------|--------------------------|--------------------------|
| Hamisch35 (2008)b     | Retrospective cohort (retropro) | RYGB            | Preop WL                         | Not predictor             | 203 102 @24 mo 43 @36 mo 20 @48 mo | 44.0       | 84.1 | NR              | 24       | NR                     | %EWL 64.4 @ 24 mo       | %EWL 57.5 @ 36 mo        | %EWL 49.8 @ 48 mo       |
|                       |                    |                 |                                  |                           |               |          |                 |          |                        |                      |                         |                          |
| Huerta28 (2008)b      | Retrospective cohort | RYGB            | Preop WL                         | Not predictor             | 60 @24       | 50 (1.3) | 30              | 49.0 (SD: 1.0) | 24 | NR                    | %EWL 59                | NR                       |                          |
| Jantz24 (2009)b       | Retrospective cohort (retropro) | RYGB            | Preop WL                         | Not predictor             | 384 @12 mo 184 @24 mo 42 @48 mo | 43.3 (9.3) | 82.6 | 48.0 (SD: 5.9) | 12-48    | 30.2 (SD: 5.0) @12 29.5 (SD: 5.5) @24 32.2 (SD: 6.4) @48 | %EWL 67 (17.9) @48 mo | NR                       |                          |
| Kalarchian27 (2016)b  | Prospective cohort (data from RCT) | LAGB, RYGB, LSG | Preop WL                         | Not predictor             | 143 117 @24 mo | 44.9 (11) | 90.2 | 45.5 (SD: 6.3) | 24       | NR                    | ±5% Preop %EWL          | %EWL 28.1                | %EWL 27.8               |
| Lipidoti7 (2011)      | Retrospective cohort | RYGB, LAGB, VBG, BPD&DS | EB; BE (EDO)                     | Not predictor             | 130 | 40.6 (9.2) | 78.5 | 45.8 (SD: 6.7) | 36       | 32.1 (SD: 6.6) | ΔBMI 13.7               | Both, self-reported (85.4%) and in clinic |
| Legenbauer52 (2011)   | Prospective cohort | LAGB            | EB: Lifetime diagnosis positive of ED | 151 97 @48 mo | 38.8 (10.3) | 66.9 | 50.9 (SD: 8.0) | 48       | 39.9 | %BMI 20.9              | In clinic by staff     |
| Marek26 (2017)        | Prospective cohort | RYGB            | EB: BED                          | Negative                 | 446 | 46.75 (11.63) | 74.2 | 49.14 (SD: 9.50) | 60       | 34.7 (SD: 7.6) | ΔBMI 14.44 & %EWL 47.5 (21.8) | In clinic               |
| Martin25 (2015)b      | Retrospective cohort (retropro) | LSG              | Preop WL                         | Not predictor             | 292 109 @24 mo | 41.5 (11.1) | 70.2 | 45.5 (SD: 7.5) | 24       | NR                    | NR                   | In clinic, some post-op weights self-reported by phone |
| Morse46 (2016)a,b     | Prospective cohort (data from RCT) | RYGB, BPD&DS | 1. EB: unspecified (EDE-Q) 2. EB: Objective bulimic episodes | 1. Not predictor 2. Positive | 60 | 35.6 (6.2) | 70 | 55.0 (SD: 3.3) | 60       | NR                    | NR                   | NR                       |
| Mrad29 (2008)b        | Retrospective cohort | VBG, RYGB, LAGB | Preop WL                         | Not predictor             | 146 26 @24 mo | 39.5 (R:18-63) | 84.2 | 52.6 (R:34-95) | 24       | NR                    | %WL 33.8              | NR                       |                          |
| Pan21 (2015)          | Prospective cohort | RYGB, LSG       | Preop WL                         | Not predictor             | 95 | 46.3 (8.8) | 88.4 | 45.8 (SD: 4.8) | 48       | NR                    | ΔBMI 10.5 (−2.7-32.5) & %TWL 21.5 (−5.9-53.6) & %EWL 44.7 (−130-109.4) | Both, self-reported and in clinic by doctor, added 2 kg to self-reported measurements |
| Pekkarinen40 (2016)a,b| Retrospective cohort | LSG, LAGB       | Preop WL 1. Preop WL 2. EB: BE (EBS) | Not predictor             | 257 223 @24 mo 218 @Med 60 mo | 48.0 (R: 24-67) | 64 | Med: 48.2 (R: 36.8-77.1) | Med: 60               | NR                    | NR                       |
| Ruiz-Tovar27 (2019)b  | Prospective cohort | LSG              | Preop WL 1. Preop WL 2. EB: snacking, sweet eating, soda drinking | 1. Positive 2 to 4. Negative | 50 | 43.2 (10.2) | 88 | 51.2 (SD: 7.9) | 24       | 27.9 (SD: 2.8) | %EWL 82.4 & WLG 45.5(10.2) | NR                       | (Continues)
TABLE 1

| Weight loss predictor/s reported | % Base BMI (kg/m2) | Female BMI (kg/m2) F/U (mo) | Mean weight loss (SD) | Mean post-op BMI (SD) | Mean weight measurement method |
|--------------------------------|-------------------|-----------------------------|-----------------------|-----------------------|--------------------------------|
| LAGB                           | Preop WL          | Positive                    | 46.2                  | 41.9 (12.8)           | 72 (SD: 4.7)                  |
| Sethi (2016)                   | Retrospective cohort | Not predictor | 43.7                  | 46.93 (R: 26-72)      | 62 (SD: 3.0)                  |
| Signorini (2018)               | Retrospective cohort | Not predictor | 43.6                  | 46.4 (SD: 10.9)       | 30 (SD: 11.2)                  |
| Thonney (2010)                 | Prospective cohort | EB; BED (EDE) | 47.9                  | 46.7 (SD: 10.4)       | 24 (SD: 11.4)                  |
| Wedin (2014)                   | Prospective cohort | EB; EE                     | 43.7                  | 46.4 (SD: 10.0)       | 30 (SD: 11.2)                  |
| White et al (2010)             | Prospective cohort | EB; EE                     | 43.7                  | 46.4 (SD: 10.0)       | 30 (SD: 11.2)                  |
| Wölnerhanssen (2008)          | Prospective cohort | EB; LOC eating (EDE) | 43.7                  | 46.4 (SD: 10.0)       | 30 (SD: 11.2)                  |
| Abbreviations: Δ, absolute difference/change in; BE, binge eating; BED, binge eating disorder; BES, binge eating scale; BMI, body mass index; BMIL, body mass index loss; BPD, biliopancreatic diversion; DS, duodenal switch; EB, eating behaviour; EBMIL, excess body mass index loss; EDE, Eating Disorder Examination; EDE-Q, Eating Disorder Examination Questionnaire; EDI-II, Eating Disorder Inventory-2; EE, emotional eating; EWL, excess weight loss; IQR, interquartile range; LAGB, laparoscopic adjustable gastric band; LOC, loss of control; RCT, randomized controlled trial; RYGB, Roux-en-Y Gastric Bypass; TWI, total weight loss; VBG, vertical banded gastroplasty; WALI, weight and lifestyle inventory; WG, weight gain; WL, weight loss. |
preoperative BED at 2 years after surgery.\textsuperscript{51} Using latent growth modelling, Marek et al reported a $\beta$ of .16 ($P = 0.008$) for BED at postoperative weight loss in their cohort of 446 patients at 60 months after surgery.\textsuperscript{50} Finally, Wölnerhanssen et al reported a hazard ratio of 1.89 (1.41-2.54) ($P < .0001$) for poorer outcomes including weight loss in those patients with BED.\textsuperscript{41} Their cohort included 380 patients and had a median follow-up interval of 5 years. The remaining four studies of fair quality reported no association between maladaptive eating behaviours and postoperative weight loss. Three of these studies used BED as their predictor,\textsuperscript{40,44,47} and one used emotional eating (EE).\textsuperscript{42}

Significant heterogeneity in the literature was found in the reported preoperative maladaptive eating behaviours as well as the methodology of identifying and measuring them (Table 3). Eight different eating behaviours were reported in our included studies. They include BED, EE, loss of control (LOC) over eating, objective bulimic episodes, snacking, diet soda drinking, sweet eating, and a lifetime diagnosis of an eating disorder (ED). In two studies the maladaptive eating behaviour was not specified. The most common eating behaviour reported was BED which was used in 9 studies. EE, LOC over eating, and snacking were reported twice. The rest of the eating behaviours were only reported once.

### 3.3 Tobacco use and substance abuse

Tobacco use was reported as a potential predictor in three studies. Two studies found no association between current tobacco use and weight loss after surgery.\textsuperscript{11,53} One study found it to be negatively associated with weight loss.\textsuperscript{33} Adams et al\textsuperscript{11} also reported a negative relationship between substance abuse and weight loss within its cohort (Table 4).

Excluding studies of poor quality, only the study by Andersen et al remained.\textsuperscript{33} Using linear regression models in their cohort of 160 patients they found a B of 13.3 (4.3-22.4) ($P = .004$) between smoking status and postoperative weight loss at 24 months follow-up.

### 3.4 Physical activity

Only one poor quality study examined the relationship between the level of preoperative physical activity and postoperative weight loss. It did not report on the way physical activity was identified or measured. Increased physical activity levels were reported to be associated with higher postoperative weight loss.\textsuperscript{10} The measure of association was not reported. Of note, this article reported findings from a younger study population, with a mean age of 39.9, and the weight loss results were self-reported (Table 4).

### 4 DISCUSSION

This review aimed to identify and investigate modifiable preoperative behavioural factors associated with weight loss outcomes at least
| Predictive association | Author (year) | Overall NOQAT score | Subgroups | F/U (months) | n | Measure of association | Size of association | P | Measure of WL | Size of L (SD) | P |
|------------------------|--------------|---------------------|-----------|-------------|---|------------------------|-------------------|---|--------------|--------------|---|
| Not Predictor          | Andersen33 (2014) | Good               | -         | 24          | 160 | B                     | -0.3 (−0.7−0.3)  
|                        |              |                     |           |             |    |                       | 945    |   |              |              |   |
|                        | Becouarn3 (2010) | Good               | LAGB      | 24          | 62  | R²                    | 0.004            |   |              |              |   |
|                        |              |                     | RYG       | 107         | 47  | R²                    | 0.008            |   |              |              |   |
|                        |              |                     | LAGB      | 36          | 47  | R²                    | 0.009            |   |              |              |   |
|                        |              |                     | RYG       | 33          | 47  | R²                    | 0.004            |   |              |              |   |
|                        | Blackledge30 (2016) | Good               | Preop WG >5% EW | 24          | 80  | NR                    | 0.931            |   |              |              |   |
|                        |              |                     | Preop WG 0-0.9% EW | 118         | 88  | NR                    | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL 0 to 0.9% EW | 60          | 42  | NR                    | 0.999            |   |              |              |   |
|                        | Brown34 (2013) | Good               | —         | 24          | 114 | R                     | -0.008           |   |              |              |   |
|                        |              |                     | WL <1 lb  | 36          | 159 | NR                    | 0.973            |   |              |              |   |
|                        |              |                     | WL 1 to 9.9 lb | 46          | 168 | NR                    | 0.931            |   |              |              |   |
|                        |              |                     | WL >10 lb  | 46          | 167 | NR                    | 0.973            |   |              |              |   |
|                        | Hannich3 (2008) | Poor               | Preop WG > 10 lb | 24          | 59  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL > 10 lb | 43          | 43  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL > 10 lb | 36          | 26  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL > 10 lb | 17          | 17  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL > 10 lb | 48          | 16  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL > 10 lb | 48          | 6   | —                     | 0.973            |   |              |              |   |
|                        | Huard28 (2008) | Poor               | Preop WG  | 48          | 6   | —                     | 0.973            |   |              |              |   |
|                        |              |                     | Preop WL  | 48          | 6   | —                     | 0.973            |   |              |              |   |
|                        | Jantz4 (2009) | Poor               | —         | 24          | 184 | OR                    | 1.70 (0.8-3.5)  
|                        |              |                     |           |             |    |                       | 0.148    |   |              |              |   |
|                        |              |                     |           |             |    |                       | 0.131    |   |              |              |   |
|                        | Kalachian37 (2016) | Poor               | ≥5% Preop %WL | 24          | 26  | —                     | 0.973            |   |              |              |   |
|                        |              |                     | <5% Preop %WL | 24          | 26  | —                     | 0.973            |   |              |              |   |
|                        | Martin35 (2015) | Poor               | —         | 24          | 109 | β                    | -0.3             |   |              |              |   |
|                        |              |                     |           |             |    |                       | 0.56    |   |              |              |   |
|                        | Metz39 (2008) | Poor               | —         | 24          | 26  | R                     | 0.973            |   |              |              |   |
|                        |              |                     |           |             |    |                       | 0.973            |   |              |              |   |
|                        | Parmi35 (2015) | Poor               | —         | 24          | 115 | β                    | -0.9 (-0.6-0.2)  
|                        |              |                     |           |             |    |                       | 0.306    |   |              |              |   |
|                        |              |                     |           |             |    |                       | 0.973            |   |              |              |   |
|                        | Negative     | Poor               | —         | 24          | 223 | β                    | -0.9 (-0.5-0.0)  
|                        |              |                     |           |             |    |                       | 0.018    |   |              |              |   |
|                        | Pekkarinen37 (2016) | Poor               | —         | 24          | 223 | β                    | -0.9 (-0.5-0.0)  
|                        |              |                     |           |             |    |                       | 0.018    |   |              |              |   |

Abbreviations: Δ, absolute difference/change in; BMIL, body mass index loss; EBMIL, excess body mass index loss; NOQAT, Newcastle-Ottawa Quality Assessment Tool; NR, not reported; NS, not significant; OR, odd ratio; TWL, total weight loss; WG, weight gain; WL, weight loss.

a95% confidence interval.
bMultivariate/Multiple regression analysis.
cSE.

P < 0.05.
## Table 3: Results from studies reporting on maladaptive eating behaviours

| Predictive association | Author (year) | Overall NOQAT score | EB measurement | Subgroups | F/U (months) | n | Measure of association | Size of association | P | Measure of WL | Size of WL (SD) | P |
|------------------------|---------------|---------------------|----------------|-----------|--------------|---|----------------------|-------------------|---|----------------|----------------|---|
| Positive               |               |                     |                |           |              |   |                      |                   |   |                |                |   |
|                        | Lehenbauer52 (2011) | Poor | Lifetime diagnosis of ED | — | 48 | 97 | β | 0.19 | .014° | %BMIL | — | — |
|                        | Morseth45 (2016)b | Poor | Objective bulimic episodes | — | 24 | 60 | NR | NR | .042° | ΔBMI | — | — |
|                        | Wedin5 (2014) | Poor | EE | — | 24 | 80 | OR | 4.95 (1.18-20.71)° | .028° | %EWL | — | — |
| Not Predictor          | Agüera49 (2015) | Poor | BED (EDI-II) | — | 24 | 139 | B and OR | NR | NS | %EWL | 59.1 (16.2) | >.05 |
|                        | Alger-Mayer58 (2009) | Poor | BE (BES) | — | 26 | 24 | 72 | — | — | — | — | %EWL | 56.7 (14.1) | >.05 |
|                        | Conceição46 (2017) | Poor | LOC, picking and/or nibbling (EDE-Q) | LAGB | Mean: 25.57 (SD: 3.57) | 44 | NR | NR | NS | %TWL | NR | NS |
|                        |                    | |                      | RYGB | Mean: 26.08 (SD: 2.82) | 17 | NR | NR | NS | %TWL | NR | NS |
|                        | Fink-Miller62 (2017) | Fair | EE (WALI) | — | 24 | 357 | β | 0.010 | .851 | %WL | 22.93 (13.62) | — |
|                        | Fujioka31 (2008) | Poor | BED | History of BED | 24 | 38 | — | — | — | — | %EWL | 70 | .33 |
|                        | Lapidoth47 (2011) | Fair | BE (EDO) | Preop BE | 36 | 24 | — | — | — | — | ΔBMI | NR | .29 |
|                        | Morseth45 (2016)b | Poor | EDE-Q | — | 60 | 60 | NR | NR | .599 | ΔBMI | — | — |
|                        | Pekkarinen40 (2016) | Fair | BE (BES) | — | 24 | 223 | NR | NR | NS | %TWL | — | — |
|                        | Thonney44 (2010) | Fair | BED (EDI-II) | — | 24 | 43 | NR | NR | NS | %EWL | 76.1 (3.4) | — |
|                        | White45 (2010) | Poor | LOC eating (EQE-Q) | Preop LOC eating | 221 | — | — | — | — | BMIL | 18.3 (6.9) | .87 |
|                        | Wölnerhanssen46 (2008) | Fair | Snacking | Med: 40 (range: 17-66) | 380 | HR | 1.18 (0.87-1.6)° | .28 | %EWL | NR | — |

(Continues)
## Table 3 (Continued)

| Predictive association | Author (year) | Overall NOQAT score | EB measurement | Subgroups | F/U (months) | n | Measure of association | Size of association | Measure of WL | Size of WL (SD) | P |
|------------------------|--------------|----------------------|----------------|-----------|--------------|---|----------------------|-------------------|----------------|-----------------|---|
| Negative               | Chao et al (2016) | Fair BED (EDE) | Preop BED | 24 | 33 | — | — | — | — | %WL | 18.6 (2.3) | .049* |
|                        | Marek et al (2017) | Fair BED | — | 60 | 446 | β | 0.16 | .008* | %EWL | 47.3 (21.8) | — |
|                        | Ruiz-Tovar et al (2015) | Poor Snacking | Snackers | 24 | 50 | — | — | — | — | %EWL | 831 | .008* |
|                        | Ruiz-Tovar et al (2015) | Poor Sweet eating | Sweet eaters | 24 | 50 | — | — | — | — | %EWL | 902 |
|                        | Ruiz-Tovar et al (2015) | Poor "Diet" soda drinking | Soda drinkers | 24 | 50 | — | — | — | — | %EWL | 783 | <.001* |
|                        | Ruiz-Tovar et al (2015) | Poor Diet soda drinking | Non-soda drinkers | 24 | 50 | — | — | — | — | %EWL | 939 |
|                        | Wölnerhanssen et al (2008) | Fair BED | Med: 40 (range: 17-66) | 380 | HR | 1.89 (1.41-2.54) | .0001* | %EWL | 832 | .022* |

Abbreviations: Δ, absolute difference/change in; BE, binge eating; BED, binge eating disorder; BES, binge eating scale; BMI, body mass index; BMIL, body mass index loss; EDE, eating disorder examination; EDE-Q, eating disorder examination questionnaire; EDI-II, eating disorder inventory 2; EE, emotional eating; EWL, excess weight loss; HR, hazard ratio; LOC, loss of control; Med, median; NOQAT, Newcastle-Ottawa Quality Assessment Tool; NR, not reported; NS, not significant; OR, odd ratio; TWL, total weight loss; WALI, weight and lifestyle inventory; WL, weight loss.

*95% confidence interval.

bMultivariate/Multiple regression analysis.

cSE.

*P < .05.
**Table 4** Results from studies reporting on tobacco use, substance abuse, and preoperative physical activity

| Preoperative factor | Predictive association | Author (year) | Overall OQAT score | Subgroups | F/U mo | n | Measure of association | Size of association | P | Measure of WL | Size of WL (SD) | P |
|---------------------|------------------------|---------------|--------------------|-----------|-------|---|------------------------|-------------------|---|----------------|----------------|---|
| Tobacco use         | Not predictor          | Adams11 (2012) | Poor               | Never smoker | 24    | 27 | –                      | –                 | – | %EBMIL        | 58.98 (27.66) | .14 |
|                     |                        |               |                    | Former smoker| 22    |    | –                      | –                 | – | %EBMIL        | 48.18 (34.32) |    |
|                     |                        |               |                    | Recent smoker| 9     |    | –                      | –                 | – | %EBMIL        | 70.11 (26.98) |    |
|                     |                        | Signorini53 (2018) | Poor               | Smoker     | 24    | 102| –                      | –                 | – | %EWL          | 68 (20)        | >.05 |
|                     |                        |               |                    | Ex-smoker   |       |    | –                      | –                 | – | %EWL          | 74 (21)        |    |
|                     |                        |               |                    | Non-smoker  |       |    | –                      | –                 | – | %EWL          | 71 (24)        | >.05 |
|                     |                        |               |                    | Smoker      | 81    | 102| –                      | –                 | – | %EWL          | 56.18 (20)     | >.05 |
|                     |                        |               |                    | Ex-smoker   |       |    | –                      | –                 | – | %EWL          | 55.07 (35)     | >.05 |
|                     |                        |               |                    | Non-smoker  |       |    | –                      | –                 | – | %EWL          | 59.17 (25)     |    |
| Negative            | Andersen33 (2014)       | Good          |                    | –          | 24    | 160| B                      | 13.3 (4.3-22.4)a | .004* | %EBMIL         | –              | – |
|                     |                        |               |                    |            |       |    | Bb                     | 10.3 (1.1-19.5)a | .029* | –              | –              | – |
| Substance abuse     | Not predictor          | Adams11 (2012) | Poor               | History of abuse | 24    | 8  | –                      | –                 | – | %EBMIL        | 47.41 (23.61) | .09 |
|                     |                        |               |                    | No history of abuse | 52    |     | –                      | –                 | – | %EBMIL        | 57.82 (31.82) |    |

**Abbreviations:** BMIL, body mass index loss; EBMIL, excess body mass index loss; NOQAT, Newcastle-Ottawa Quality Assessment Tool; NR, not reported; WL, weight loss.

a95% confidence interval.
bMultivariate/Multiple regression analysis.

*P < .05.
become almost historical.\textsuperscript{55} LAGB is also falling out of favour following disappointing weight loss outcomes and significant postoperative complication rates requiring re-intervention.\textsuperscript{29,32} LSG is becoming one of the most commonly performed operations.\textsuperscript{1}

The main limitation was substantial heterogeneity in predictor and outcome reporting which lead to difficulties in data synthesis. This includes difficulties in performing meta-analyses or calculating formal measures of heterogeneity, such as I\textsuperscript{2}. Eight different weight loss-related outcomes were used, the most common being %EWL. In addition to the problem of comparisons and meta-analysis, these varying measurement methods can also lead to different interpretations of results. The same amount of weight loss can be statistically significant using one measurement method and not significant if using another, as seen in Sethi et al.\textsuperscript{36}

An additional limitation is the risk of confirmation bias in the literature with regards to preoperative weight loss. It is common practice for preoperative weight loss to be a prerequisite for bariatric surgery. This is separate and in addition to a history of weight loss attempts prior to being considered for surgery. This leads to reporting of findings derived only from people that lost weight prior to their operation.\textsuperscript{37}

Further studies reporting the long-term outcomes of bariatric surgery are needed. In our experience there were more than twice as many studies reporting outcomes with less than 2 years of follow-up. This is particularly the case in literature reporting on modifiable predictors. In the systematic review by Livhits et al in 2012 findings for many studies reporting outcomes with less than 2 years of follow-up times of greater than 2 years, compared to only 13 of 53 articles on modifiable predictors. The relative lack of published outcomes in those with more than 2 years of follow-up raises the question of a potential publication bias. Long term data is required even if they demonstrate inadequate or negative results.

The issues around heterogeneous outcome reporting in bariatric surgery are not unrecognized. Both the American Society for Metabolic and Bariatric Surgery (ASMBS) and the BARIACT project have recently raise this issue and made efforts to standardize outcome reporting.\textsuperscript{56,57} They include new outcome reporting guidelines that should help homogenize outcome measures and make this literature more amenable to quantitative analysis in future reviews.

Finally, more information is required to elucidate the role of alcohol use, tobacco, use, and substance abuse as predictors of postoperative outcomes, especially their relationship with behaviours and eating disorders in modulating bariatric outcomes.\textsuperscript{58} In the postoperative period, there is some evidence that preoperative maladaptive eating behaviours is associated with vulnerability to other addiction disorders.\textsuperscript{8}

5 | CONCLUSION

The search for preoperative predictors of postoperative outcomes continues within bariatric surgery. This review suggest that preoperative weight loss is likely to be a positive or non-predictor of postoperative weight loss and maladaptive eating behaviours may be a negative or non-predictor. Tobacco use may be a negative predictor. There was insufficient data to make conclusions on physical activity, and substance abuse as predictors. The main strengths of this review were the inclusion of recent studies, and a minimum follow-up interval of 2 years after surgery. The main limitation was widespread heterogeneity and inconsistent outcome reporting which made it difficult to analyse the currently available evidence. Strong clinical implications are difficult to discern, although the use of preoperative weight loss appears to be beneficial, while the strict use of preoperative maladaptive eating behaviours as barriers to being considered for surgery may not be appropriate in all cases. Further studies investigating these behaviours with >2-year postoperative outcomes are needed. The use of common predictor and outcome measures in further studies is vital for the meta-analysis of future evidence.

ACKNOWLEDGEMENTS

This research was undertaken as part of the third year of the MSIC in Surgical Sciences at the University of Edinburgh. The authors are grateful to Marshal Dozier for helping in optimizing and finalizing the search strategies, Chia Yew Kong for accepting the task of being second independent reviewer, Stephen McSorley for offering support on methods of assessing bias, and Thomas Drake and Stephen Knight for their help on statistics.

AUTHOR CONTRIBUTIONS

Georgios Kourounis, Simon Gibson and Jennifer Logue conceived the article. Georgios Kourounis, Chia Yew Kong and Jennifer Logue contributed to data extraction. Georgios Kourounis generated the figures. All authors contributed to the study design, data analysis, data interpretation and write-up of the manuscript.

CONFLICTS OF INTEREST

No conflict of interest was declared.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Kourounis G, Kong CY, Logue J, Gibson S. Weight loss in adults following bariatric surgery, a systematic review of preoperative behavioural predictors. Clin Obes. 2020;10:e12392. https://doi.org/10.1111/cob.12392