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REVIEW ARTICLE

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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. Most articles on PWL (72.2%) and MEB (52.4%) reported no association. 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.[1] Evidence supports the efficacy of bariatric surgery to produce safe large-scale weight loss,[2,3] yet outcomes are not always favourable. Reports range from 10% to 50% of patients not achieving the desired weight loss following surgery.[4,5] 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.[8] 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.

What is already known about this subject?

- Bariatric surgery is an effective therapy in the management of patients with obesity, yet in some patients significant weight loss is not achieved or maintained in the longer term.
- Multiple predictors of weight loss have been investigated, a proportion of which are behavioural and modifiable meaning they could be utilized preoperatively to optimize outcomes.
- Modifiable behaviours are already being used in other surgical disciplines through prehabilitation programmes to optimize outcomes.

What this study adds?

- Highlights ongoing ambiguity and lack of strong evidence regarding behavioural predictors, perhaps challenging the strict use of behavioural factors as barriers to surgical treatments
- Reinforces urgent need for use of common outcome measures to allow robust synthesis of findings.
- Demonstrates paucity of literature reporting long term outcomes following bariatric surgery.

2 | 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 al[8,12] 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.

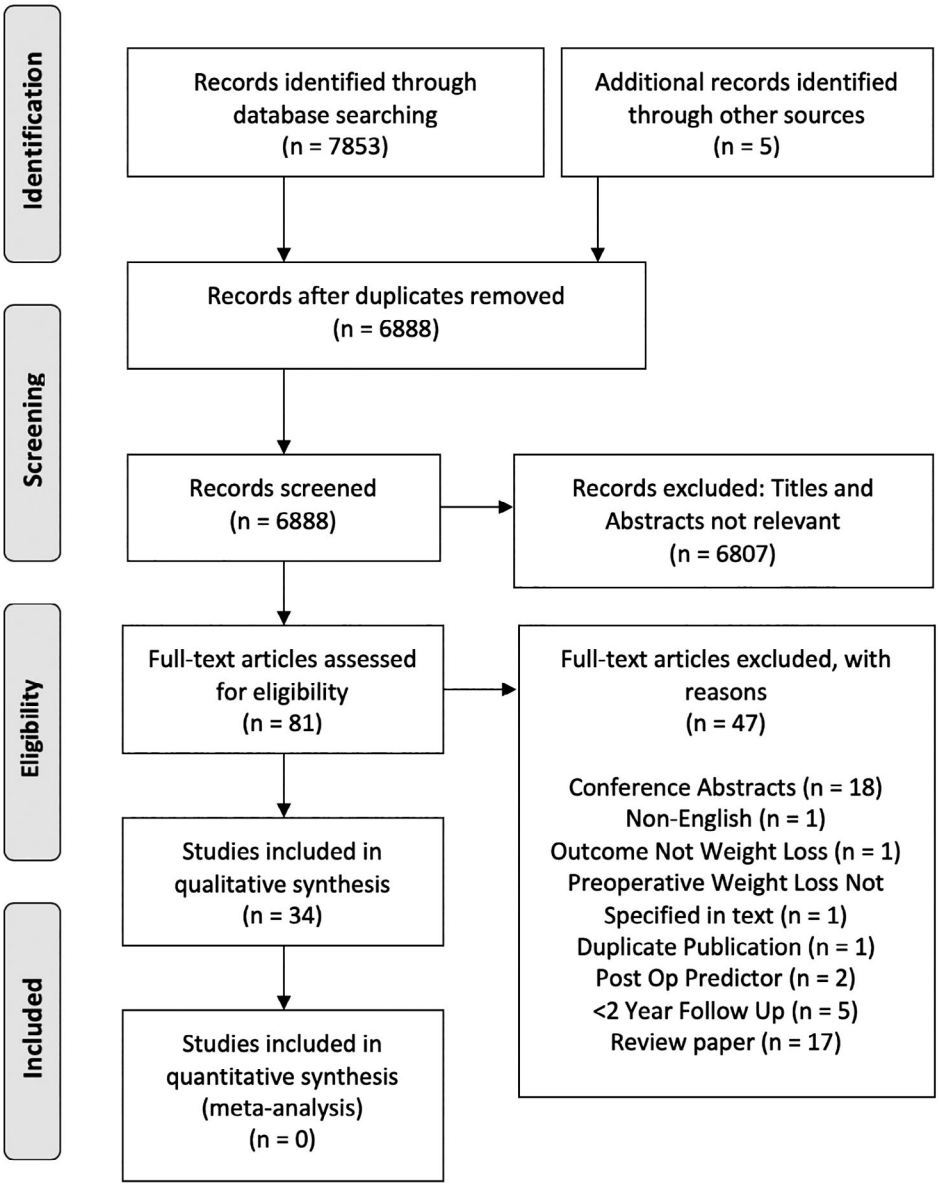

FIGURE 1 PRISMA flow diagram of review.
Source: From Moher et al[59]

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/m^2 and the majority of cohorts had an average preoperative BMI between 42 and 50 kg/m^2. 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]

TABLE 1 Description of studies included in the review

Author (year)	Study design	Operation(s)	Weight loss predictor/s reported	Predictive value	Patients[a]	Mean age (SD)	% Female	Base BMI (kg/m^2)	F/U (mo)	Mean post-op BMI (kg/m^2)	Mean weight loss (SD)	Weight measurement method
Adams[11] (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)	%EBMIL 56.92 (30.75)	NR
Agüera[49] (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-Mayer[38] (2008)	Prospective cohort	RYGB	Preop WL	Positive	291 150 @ 36 mo 95 @ 48 mo	45.3 (8.9)	80	52.2 (SD: 9.8)	36	35.4 (SD: 8.2)	@ 36 mo %TBWL 31.9 (11.7) %EWL 55.1 (20.2) @ 48 mo %TBWL 29.4%(11.5) %EWL 50.8 (19.8%)	NR
Alger-Mayer[48] (2009)[b]	Prospective cohort	RYGB	EB; BE (BES)	Not predictor	157 95 @24 mo	45 (10)	86	50.7 (SD: 8.0)	24	NR	%TBWL 34.3 (9.1) %EWL 61 (16)	NR
Andersen[33] (2014)[a]	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
Becouarn[32] (2010)	Retrospective cohort	LAGB	Preop WL	Not predictor	97	40.9 (10.1)	NR	45.3 (SD: 6.8)	36	NR	%EWL 58.9 (27.8)	In clinic
		RYGB			381	41.2 (10.7)		45.6 (SD: 6.8)			%EWL 48.8 (25.9)	
		LSG			29	53.4 (10.9)		47.9 (SD: 11.0)			%EWL 68.9 (20.4)	
Blackledge[30] (2016)	Retrospective cohort	RYGB	Preop WL	Not predictor	300	44 (IQR;37-52)	75	47.3 (IQR:42.4-53.1)	24	NR	Overall NR, subgroup results in Table 4	In clinic
Brown[34] (2013)	Retrospective cohort (retropro)	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
Chao[51] (2016)[b]	Prospective cohort	RYGB, LAGB	EB; BED (EDE)	Negative	92 77 @24 mo	44.9	79.3	49.43	24	NR	%WL 22.0	In clinic
Conceição[46] (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)	In clinic
		RYGB			17	37.06 (7.43)		47.24 (SD: 3.53)	26.08 (SD: 2.82)	30.06 (SD: 4.2)	%TWL 36.36 (7.51) %EBMIL 78.58 (18.66) %EWL 70.95 (15.77)	
Fink-Miller[42] (2017)	Retrospective cohort	RYGB	EB; EE (WALI)	Not predictor	357	45.06 (11.83)	77.9	48.72 (SD: 9.22)	24	37.52 (SD: 9.85)	ΔBMI 11.2	In clinic, by nurse
Fujioka[31] (2008)[a,b]	Retrospective cohort	RYGB	1. Preop WL 2. EB; BED	1. Not predictor 2. Not predictor	121 104 @24 mo	48 (R:23-70)	83	49.2 (R:35.2-71.6)	24	NR	NR	NR
Gallo[26] (2008)	Retrospective cohort	LAGB	Preop WL	Not Predictor	415	*WL < 1 lb* 43 (10)	84	47 (SD: 8)	36	NR	%EWL 38 (26)	NR
						WL 1-9.9 lb 41 (10)		45 (SD: 9)			%EWL 51 (30)	
						WL > 10 lb 39 (11)		47 (SD: 8)			%EWL 42 (25)	
Gerber[39] (2016)	Prospective cohort	RYGB	Preop WL	Positive	9570	42	77.2	42.0 (IQR: 38.6-45.4)	24	28.4 (IQR: 25.4-31.6)	ΔBMI 13.6	NR (Source: SOReg records)
Goldenshluger[10] (2017)	Retrospective cohort	LSG	Preop PA	Positive	178	39.9 (11.2)	68	42.9 (SD: 4.5)	36 (R:24-53)	NR	%TWL 30.31 (9.9) %EWL 74.32 (23.92)	Self-reported

TABLE 1 (Continued)

Author (year)	Study design	Operation(s)	Weight loss predictor/s reported	Predictive value	Patients[a]	Mean age (SD)	% Female	Base BMI (kg/m^2)	F/U (mo)	Mean post-op BMI (kg/m^2)	Mean weight loss (SD)	Weight measurement method
Harnisch[35] (2008)[b]	Retrospective cohort (retropro)	RYGB	Preop WL	Not predictor	203 102 @24 mo 43 @36 mo 20 @48 mo	*Preop WL > 10 lb* 44.0 *Preop WG > 10 lb* 41.4	84.1 85.2	NR	24	NR	%EWL 64.4 @ 24 mo %EWL 57.5 @ 36 mo %EWL 49.8 @ 48 mo %EWL 66.9 @ 24 mo %EWL 70.9 @ 36 mo %EWL 66.6 @ 48 mo	Preop NR, Post op in clinic
Huerta[28] (2008)[b]	Retrospective cohort	RYGB	Preop WL	Not predictor	40 6 @24	50 (1.3)	30	49.0 (SD: 1.0)	24	NR	%TBWL 59	NR
Jantz[24] (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
Kalarchian[27] (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 %WL* %WL 28.1 *<5% Preop %WL* %WL 27.8	In clinic
Lapidoth[47] (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
Legenbauer[52] (2011)	Prospective cohort	LAGB	EB; Lifetime diagnosis of ED	Positive	151 97 @48 mo	38.8 (10.3)	66.9	50.9 (SD: 8.0)	48	39.9	%BMIL 20.9	In clinic, by staff
Marek[50] (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
Martin[25] (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
Morseth[45] (2016)[a]	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
Mrad[29] (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
Parri[23] (2015)	Prospective cohort	RYGB, LSG	Preop WL	Not predictor	95	46.3 (8.8)	88.4	45.8 (SD: 4.8)	48	NR	NR	In clinic
Pekkarinen[40] (2016)[a,b]	Retrospective cohort	LSG, RYGB	1. Preop WL 2. EB; BE (BES)	1. Negative 2. Not predictor	257 223 @24 mo 218 @Med 60 mo	Med: 48.0 (R: 24-67)	64	Med: 48.2 (R: 36.8-77.1)	Med: 60	NR	ΔBMI 10.5 (−2.7-32.6)[c] %TWL 21.5 (−5.9-53.6)[c] %EWL 44.7 (−13.0-109.4)[c]	Both, self-reported and in clinic by doctor, added 2 kg to self-reported measurements
Ruiz-Tovar[37] (2015)[a]	Prospective cohort	LSG	1. Preop WL 2 to 4. 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 WL 45.5(10.2) kg	NR

(Continues)

TABLE 1 (Continued)

Author (year)	Study design	Operation(s)	Weight loss predictor/s reported	Predictive value	Patients[a]	Mean age (SD)	% Female	Base BMI (kg/m^2)	F/U (mo)	Mean post-op BMI (kg/m^2)	Mean weight loss (SD)	Weight measurement method
Sethi[36] (2016)	Retrospective cohort (retropo)	LAGB	Preop WL	Positive	462	41.9 (12.8)	72	45 (SD: 6.7)	24	NR	%EWL 43.6%	NR
Signorini[53] (2018)	Retrospective cohort (retropro)	LSG	Tobacco use	Not predictor	102	48.93 (R: 26-72)	62	45.44 (SD: 8)	81	34.35 (SD: 8)	%EWL 56.96% (27)	NR
Thonney[44] (2010)	Prospective cohort	RYGB	EB; BED (EDI-II)	Not predictor	43	39.2 (1.4)	100	44.7 (SD: 0.4)	24	NR	%EWL 76.1 (3.4)	In clinic, by dietician
Wedin[15] (2014)	Prospective cohort	RYGB, LSG, LAGB	EB; EE	Positive	80	47.4 (11.2)	82.5	50.9 (SD: 11.2)	24	NR	%EWL 57.14	NR
White[43] (2010)[b]	Prospective cohort	RYGB	EB; LOC eating (EDE-Q)	Not predictor	361 171 @24 mo	43.7 (10.0)	86.14	51.1 (SD: 8.4)	24	NR	NR	Both self-reported and in clinic by staff
Wölnerhanssen[41] (2008)[a]	Prospective cohort	LAGB	1 to 3. EB; BED, sweet eating, snacking	1 to 2. Negative 3. Not predictor	380	Med: 60 (Range: 18-113)	78	43.4 (R: 35-75)	60 (R: 18-113)	NR	NR	NR

Abbreviations: Δ, absolute difference/change in; BE, binge eating; BED, bing 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; ED, eating disorder; 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; LSG, laparoscopic sleeve gastrectomy; Med, median; NR, not reported; PA, physical activity; RCT, randomized clinical trial; RYGB, Roux-en-Y Gastric Bypass; TWL, total weight loss; VBG, vertical banded gastroplasty; WALI, weight and lifestyle inventory; WG, weight gain; WL, weight loss.

[a]More than one predictor reported per article.

[b]Studies reporting follow-up attrition.

[c]Median (range).

Four studies showed a positive association,[36-39] and one study found a negative association.[40] Table 2 summarizes the results of the individual studies. Percent Excess Weight Loss (%EWL) was the measurement used to report weight loss outcomes in 13 of the 18 studies. The other five studies used five different measurements.

After excluding studies of poor quality, seven of the 18 studies remained. Four of these were deemed good quality[30,32-34] (Table 2). All of these showed a no association between preoperative weight loss and postoperative weight loss. Three studies were deemed fair quality,[23,39,40] with one in each group of predictive associations. Gerber et al reported a positive association in a cohort of 9570 at 24 months postoperatively.[39] They categorized patients into percentiles of preoperative weight loss. In the 50th vs 25th percentile groups they found an odd ratio (OR) of 1.35 (1.23-1.51) ($P < .001$) for postoperative relative weight change. This increased in the 75th vs 25th percentile groups with an OR of 1.88 (1.66-2.12) ($P < .001$) for postoperative relative weight change. Parri et al found no association in a cohort of 115 patients at 24 months postoperatively.[23] Pekkarinen et al were the only to report a negative association in a cohort of 223 patients at 24 months postoperatively.[40] In a univariate regression they found a β of −0.29 (−0.53 to −0.05) ($P = .018$). However, this association became non predictive in the subset of 218 patients where longer follow-up was available. In this subset with a 5 year median follow-up they reported a β of −0.19 (−0.45 to −0.07) ($P = .152$).

The methods of achieving preoperative weight loss among studies varied greatly (Table S2). This ranged from advice at a preoperative appointment to supervised programmes of dieting and physical exercise. Two studies did not specify the method of weight loss but described the number of previous weight loss attempts and maximum weight loss. One study did not specify the method of preoperative weight loss or how it was measured.

3.2 | Eating behaviours

Sixteen studies reported on eating behaviours as factors associated with postoperative weight loss. Four of these studies reported on multiple eating behaviours making the total number of reported factors 21. Eating behaviours were found to be non-predictive of postoperative weight loss in 11 studies.[31,40-49] A negative relationship was found in four studies,[37,41,50,51] while a positive relationship was found in three studies.[15,45,52] Table 3 summarizes the results of these studies. Eight different outcome measures to report weight loss were used. %EWL was the most common and was reported six times.

When excluding studies of poor quality, seven of the 16 studies remained, all of which were deemed of fair quality[40-42,44,47,50,51] (Table 3). Of note, all of the studies reporting a positive association between preoperative maladaptive eating behaviours and postoperative weight loss were or poor quality. Three of the four studies reporting a negative association were of fair quality and all used binge eating disorder (BED) as their predictor.[41,50,51] Chao et al showed an average % Weight Loss of 18.6% in 33 patients with preoperative BED compared to 23.9% ($P = .049$) in 59 patients without

preoperative BED at 2 years after surgery.[51] Using latent growth modelling, Marek et al reported a β of .16 (P = 0.008) for BED at postoperative weight loss in their cohort of 446 patients at 60 months after surgery.[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.[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,[40,44,47] and one used emotional eating (EE).[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.[11,53] One study found it to be negatively associated with weight loss.[33] Adams et al[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.[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.[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

TABLE 2 Results from studies reporting on preoperative weight loss

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
Positive	Alger-Mayer[38] 2008)	Poor	–	36	150	R	0.302	.0002*	%TBWL	31.9 (11.7)	–
						R	0.225	.006*	%EWL	55.1 (20.2)	
				48	95	R	0.247	.016*	%TBWL	29.4 (11.5)	
						R	0.205	.046*	%EWL	50.8 (19.8)	
	Gerber[39] 2016)	Fair	50th vs 25th percentile	24	9570	OR	1.35 (1.23-1.51)[a]	<.001*	Δ%BMIL	−5.3	NR
			75th vs 25th percentile				1.88 (1.66-2.12)[a]	<.001*		−10.1	NR
	Ruiz-Tovar[37] 2015)	Poor	Combined	24	50	R	0.822	.012*	%EWL	–	–
						R	0.573	.001*	WL		
			Preop %EWL >15%			–	–	–	%EWL	94.1	.002*
			Preop %EWL <15%							81.5	
	Sethi[36] 2016)	Poor	Prior WL 0 lb	24	33	–	–	–	%EWL	41.4 (3.4)[c]	0.158
			Prior WL 1 to 20 lb		205					43.2 (1.4)[c]	
			Prior WL 21 to 50 lb		154					43.6 (1.6)[c]	
			Prior WL >50 lb		70					46.1 (2.3)[c]	
			Prior WL 0 lb	24	33	–	–	–	%BMIL	20.5 (1.7)[c]	.0008*
			Prior WL 1 to 20 lb		205					21.5 (0.7)[c]	
			Prior WL 21 to 50 lb		154					22.3 (0.8)[c]	
			Prior WL >50 lb		70					24.4 (1.2)[c]	

(Continues)

TABLE 2 (Continued)

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	Andersen[33] 2014)	Good	-	24	160	B	−0.3 (−7.9-7.3)[a]	.945	%EBMIL	—	—
						B[b]	3.3 (−4.2-10.9)[a]	.385			
	Becouarn[32] (2010)	Good	LAGB	24	62	R^2	0.004	.973	%EWL	—	—
			RYGB		107	R^2	0.000	.999			
			LAGB	36	47	R^2	0.008	.543			
			RYGB		33	R^2	0.009	.599			
			LAGB	48	38	R^2	0.004	.711			
			RYGB		13	R^2	0.231	.062			
	Blackledge[30] (2016)	Good	Preop WG >5% EW	24	80	NR	NR	NS	%EWL	68.7 (61.1-76.3)[a]	0.41
			Preop WG 0-0.99% EW		118					64.1 (78.8-70.4)[a]	
			Preop WL 0 to 0.99% EW		60					61.4 (53.9-68.8)[a]	
			Preop WL >5% EW		42					69.4 (57.9-80.9)[a]	
	Brown[34] (2013)	Good	—	24	114	R	−0.008	.931	%EWL	—	—
						β[b]	−0.01	.335			
	Fujioka[31] (2008)	Poor	—	24	104	R	0.035	.767	%EWL	—	—
	Gallo[26] (2008)	Poor	WL <1 lb	36	159	NR	NR	NS	%EWL	38 (26)	NR
			WL 1 to 9.9 lb		168					51 (30)	
			WL >10 lb		167					42 (25)	
	Harnisch[35] (2008)	Poor	Preop WG > 10 lb	24	59	—	—	—	%EWL	66.9	0.51
			Preop WL > 10 lb		43					70.9	
			Preop WG > 10 lb	36	26					66.6	.02*
			Preop WL > 10 lb		17					64.4	
			Preop WG > 10 lb	48	16					57.5	.04*
			Preop WL > 10 lb		4					49.8	
	Huerta[28] (2008)	Poor	Preop WG	48	6	—	—	—	%TBWL	57%	0.46
			Preop WL		6					62%	
	Jantz[24] (2009)	Poor		24	184	OR	1.70 (0.88-3.51)[a]	.148	%EWL	—	—
				48	42	OR	0.83 (0.66-1.06)[a]	.131			
	Kalarchian[27] (2016)	Poor	≥5% Preop %WL	24	117	—	—	—	%WL	28.1	0.37
			<5% Preop %WL			—	—			27.8	
	Martin[25] (2015)	Poor	—	24	109	β	−0.3	.56	%EWL	—	—
						R^2	<0.01	—			
	Mrad[29] (2008)	Poor	—	24	26	R	0.08	.64	%WL	33.81	—
	Parri[23] (2015)	Fair	—	24	115	β	−0.2 (−0.6-0.2)[a]	.306	%EWL	—	—
				36	105	β	0.0 (−0.4-0.3)[a]	.857			
				48	95	β	−0.2 (−0.6-0.2)	.275			
Negative	Pekkarinen[40] (2016)	Fair	—	24	223	β	−0.29 (−0.53 to −0.05)[a]	.018 *	%TWL	—	—
						β[b]	−0.37 (−0.59 to −0.14)[a]	.001 *			
				>24	218	β	−0.19 (−0.45 to −0.07)[a]	.152			
						β[a]	−0.25 (−0.51 to −0.02)[a]	.05			

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.

[a]95% confidence interval.

[b]Multivariate/Multiple regression analysis.

[c]SE.

*$P < 0.05$.

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	Legenbauer[52] (2011)	Poor	Lifetime diagnosis of ED	—	48	97	β	0.19	.014*	%BMIL	—	—
	Morseth[45] (2016)[b]	Poor	Objective bulimic episodes	—	24	60	NR	NR	.042*	ΔBMI	—	—
					60		NR	NR	.013*			
	Wedin[15] (2014)	Poor	EE	—	24	80	OR	4.95 (1.18-20.71)[a]	.028*	%EWL	—	—
Not Predictor	Agüera[49] (2015)	Poor	BED (EDI-II)	—	24	139	B and OR	NR	NS	%EWL	NR	—
	Alger-Mayer[48] (2009)	Poor	BE (BES)	BES ≦26	24	72	—	—	—	%EWL	59.1 (16.2)	>.05
				BES ≧27		23					66.7 (14.1)	
				BES ≦26	36	45					53.7 (17.5)	>.05
				BES ≧27		16					65.0 (14.9)	
				BES ≦26	48	28					50.3 (18.9)	>.05
				BES ≧27		11					61.5 (15.5)	
				BES ≦26	60	18					55.8 (20.5)	>.05
				BES ≧27		5					49.3 (5.1)	
				BES ≦26	72	16					53.7 (24.0)	>.05
				BES ≧27		4					46.4 (9.2)	
	Conceição[46] (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		NR	NS
	Fink-Miller[42] (2017)	Fair	EE (WALI)	—	24	357	β	0.010	.851	%WL	22.93 (13.62)	—
	Fujioka[31] (2008)	Poor	BED	History of BED	24	38	—	—	—	%EWL	70	.33
				No history of BED		74					65	
	Lapidoth[47] (2011)	Fair	BE (EDO)	Preop BE	36	24	—	—s	—	ΔBMI	NR	.29
	Morseth[45] (2016)[b]	Poor	EDE-Q	—	60	60	NR	NR	.599	ΔBMI	—	—
	Pekkarinen[40] (2016)	Fair	BE (BES)	—	24	223	NR	NR	NS	%TWL	—	—
					>24	218	NR	NR	NS			
	Thonney[44] (2010)	Fair	BED (EDI-II)	—	24	43	NR	NR	NS	%EWL	76.1 (3.4)	—
	White[43] (2010)	Poor	LOC eating (EQE-Q)	Preop LOC eating		221	—	—	—	BMIL	18.3 (6.0)	.87
				No Preop LOC eating		131					20.5 (6.9)	
	Wölnerhanssen[41] (2008)	Fair	Snacking	—	Med: 40 (range: 17-66)	380	HR	1.18 (0.87-1.6)[a]	.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	P	Measure of WL	Size of WL (SD)	P
Negative	Chao[51] (2016)	Fair	BED (EDE)	Preop BED	24	33	–	–	–	%WL	18.6 (2.3)[c]	.049*
				Non preop BED		59					23.9 (1.6)[c]	
	Marek[50] (2017)	Fair	BED	–	60	446	β	0.16	.008*	%EWL	47.5 (21.8)	–
	Ruiz-Tovar[37] (2015)	Poor	Snacking	Snackers	24	50	–	–	–	%EWL	83.1	.008*
				Non-snackers							90.2	
			Sweet eating	Sweat eaters	24	50					78.3	<.001*
				Non-sweat eaters							93.9	
			"Diet" soda drinking	Soda drinkers	24	50					83.2	.022*
				Non-soda drinkers							92.8	
	Wölnerhanssen[41] (2008)	Fair	BED	–	Med: 40 (range: 17–66)	380	HR	1.89 (1.41-2.54)[a]	<.0001*	%EWL	NR	–
			Sweet eating				HR	1.44 (1.06-1.97)[a]	.02*			

Abbreviations: Δ, absolute difference/change in; BE, binge eating; BED, bing 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.

[a]95% confidence interval.

[b]Multivariate/Multiple regression analysis.

[c]SE.

*$P < .05$.

2 years following bariatric surgery. Within the last decade, the factors that were investigated and fulfilled our inclusion criteria were preoperative weight loss, maladaptive eating behaviours, tobacco use, substance abuse and physical activity. The analysis in this review was hindered by substantial heterogeneity in both predictor and outcome reporting with equivocal available evidence between these factors and postoperative weight loss. Evidence from good and fair quality studies alone however suggests that preoperative weight loss is either a positive or non-predictor, maladaptive eating behaviours, especially BED, being negative or non-predictors, and tobacco use being a negative predictor.

These findings are in keeping with similar past reviews focussed on a shorter follow-up time. In a review of 15 articles by Livhits et al in 2009, preoperative weight loss was found to be a positive predictor of postoperative weight loss at 12 months after surgery.[13] Of the 15 included studies however, only three had follow-up periods of longer than 12 months. Of these, two reported an inconclusive association. All studies with less than 12 months follow-up showed a positive association. These findings show a similar pattern of a decreasing amount of positive association with longer follow-up periods. Maladaptive eating behaviours were investigated in another systematic review by Livhits et al in 2012.[8] They identified 38 articles reporting on 11 different types of maladaptive eating behaviours. Of these, 21 showed no association with postoperative weight loss. The most common maladaptive eating behaviour was BED with 20 articles. Of these, 13 found no association, four found a negative association, and three found a positive association. Although the included studies reported on shorter follow-up times than our review, they are in keeping with our findings both in their direction of association, as well as the heterogeneity of predictor reporting.

There is a substantial volume of literature that has investigated non-modifiable and non-behavioural predictors. These were not included in this review as they would not be applicable to the preoperative optimisation of patients. Although not investigated in this review, such predictors are not without value. They have been used to design risk stratification tools[54] and could provide valuable information in guiding research on other aspects of care for patients considered for bariatric surgery.

The main strengths of this review are the inclusion of studies with a minimum follow-up of 2 years that have been published within the last decade. Evidence suggests that short-term and long-term outcomes following bariatric surgery are different and that long-term results only become apparent following the two-year mark. The majority of patients lose the most weight in the first 6 to 12 months following their operation with a plateau seen between the first and second postoperative year and subsequent weight loss stabilization after 18 to 24 months.[15-19] Of note, in patients with BED a "honeymoon period" between 12 and 18 months postoperatively has been described as the period before differences in outcomes compared to those patients without preoperative BED become apparent.[48] Additionally, articles published more than a decade ago were excluded in an effort to include results that were most up to date and reflective of current bariatric surgery practice. Some operations, like VBG, have

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	Adams[11] (2012)	Poor	Never smoker	24	27	—	—	—	%EBMIL	58.98 (27.66)	.14
				Former smoker		22					48.18 (34.32)	
				Recent smoker		9					70.11 (26.98)	
		Signorini[53] (2018)	Poor	Smoker	24	102	—	—	—	%EWL	68 (20)	>.05
				Ex-smoker							74 (21)	
				Non-smoker							71 (24)	>.05
				Smoker	81	102					56.18 (20)	
				Ex-smoker							55.07 (35)	>.05
				Non-smoker							59.17 (25)	
	Negative	Andersen[33] (2014)	Good	—	24	160	B	13.3 (4.3–22.4)[a]	.004*	%EBMIL	—	—
							B[b]	10.3 (1.1-19.5)[a]	.029*			
Substance abuse	Not predictor	Adams[11] (2012)	Poor	History of abuse	24	8	—	—	—	%EBMIL	47.41 (23.61)	.09
				No history of abuse		52					57.82 (31.82)	
Physical activity	Positive	Goldenshluger[10] (2017)	Poor	—	Mean: 36 (range: 24–53)	178	NR	NR	.008*	%EWL	—	—

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

[a]95% confidence interval.

[b]Multivariate/Multiple regression analysis.

*$P < .05$.

become almost historical.[55] LAGB is also falling out of favour following disappointing weight loss outcomes and significant postoperative complication rates requiring re-intervention.[29,32] LSG is becoming one of the most commonly performed operations.[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^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.[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.[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 both modifiable and non-modifiable predictors were reported.[8] Thirty-five of 62 included articles on non-modifiable predictors had 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.[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.[58] In the postoperative period, there is some evidence that preoperative maladaptive eating behaviours is associated with vulnerability to other addiction disorders.[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.

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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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