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Is weight regain after bariatric surgery associated with psychiatric comorbidity? A systematic review and meta-analysis

Maria Francisca F.P. Mauro[1] | Marcelo Papelbaum[1] | Marco Antônio Alves Brasil[2] | João Regis Ivar Carneiro[2] | Evandro Silva Freire Coutinho[3] | Walmir Coutinho[4] | José Carlos Appolinario[1]

[1] Obesity and Eating Disorders Group, Institute of Psychiatry, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

[2] Clementino Fraga Filho University Hospital, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

[3] Department of Epidemiology, Oswaldo Cruz Foundation, Fiocruz, Rio de Janeiro, Brazil

[4] Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil

Correspondence
Maria Francisca F. P. Mauro, Obesity and Eating Disorders Group, Institute of Psychiatry, Federal University of Rio de Janeiro, 71 Avenue Venceslau Braz, Rio de Janeiro RJ 22290-140, Brazil.
Email: mffpmauro@gmail.com

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Summary

Bariatric surgery has been recognized as the gold standard treatment for severe obesity. Although postbariatric surgery patients usually achieve and maintain substantial weight loss, a group of individuals may exhibit weight regain. Several factors are proposed to weight regain, including psychiatric comorbidity. The objective of the study is to conduct a systematic review and meta-analysis of studies investigating the relationship between psychiatric comorbidity and weight regain. A systematic review through PubMed, Web of Science, Cochrane Library, Scopus, and PsycINFO was performed, following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). After a stepwise selection, 13 articles were included in the qualitative analysis and 5 were included for a meta-analysis. Women was majority in most of the studies (87.6%), and a bypass procedure was the bariatric intervention most evaluated (66.8%), followed by gastric banding (32.1%) and sleeve (1.1%). Higher rates of postbariatric surgery eating psychopathology were reported in patients with weight regain. However, the association between general psychopathology and weight regain was not consistent across the studies. In the meta-analysis, the odds of eating psychopathology in the weight regain group was higher compared with the nonweight regain group (OR = 2.2, 95% CI 1.54-3.15). Postbariatric surgery eating psychopathology seems to play an important role in weight regain.

KEYWORDS

bariatric surgery, eating disorders, psychopathology, weight gain

Abbreviations: BS, bariatric surgery; WR, weight regain; BMI, body mass index; EWL, excess weight loss; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SCID-IV, Structured Clinical Interview for DSM-IV; EDE, Eating Disorder Examination; BDI, Beck Depression Inventory; TFEQ, Three-Factor Eating Questionnaire; BSQ, Body Shape Questionnaire; kg, kilogram; NOS, Newcastle-Ottawa Quality Assessment Scale; Stata, 14.0 Stata Corporation, College Station, TX, USA; RR, relative risk; kg/m^2, kilogram/$meter^2$; EDE-Q, Eating Disorder Examination-Questionnaire; BIS-11, Barrat Impulsivity Scale; OR, odds ratio; CI, confidence interval; LAGB, laparoscopic gastric banding; LRYGB, laparoscopic Roux-en-Y gastric bypass; OQ45.2, Outcome Questionnaire-45.2; LOC, loss of control; P&N, picking and nibbling; BED, binge eating disorder; BE, binge eating episodes; NES, night eating syndrome; EI, eating inventory; ADHD, attention-deficit hyperactivity disorder; LABS-2, Longitudinal Assessment of Bariatric Surgery-2

1 | INTRODUCTION

Obesity is considered a severe and costly chronic disease, impacting individuals, societal health, and psychological well-being.[1,2] Bariatric surgery (BS) has been recognized as the gold standard treatment for clinical-resistant obesity.[3,4] Weight loss is a major outcome of BS, although hormonal and metabolic changes are associated with long-term remission after surgery.[3,5] Weight loss rates are higher during

the first year after BS, with attenuation during the following years.[4,6] Experts consider an adequate weight loss, a decrease in approximately 25% to 30% of the initial weight during the first postoperative year.[3,7] There is some evidence that the risk of weight regain (WR) increases at 18 months following BS.[4,8,9]

WR in BS could be generally defined as any weight increase observed after the patient reaches the lowest postoperative weight. However, there is no consensus regarding the clinical definition of WR (standardization of the WR measure parameters, amount of WR, minimal timeframe to the WR onset).[4,9,10] WR prevalence is estimated to range between 5% and 20%,[3] whereas an amount of 5% to 10% of WR from de nadir weight is expected and considered normal after 18 to 24 months of BS.[3,4,11] The lack of standardized WR parameters and their clinical implications also creates conflicting results between studies and makes comparisons challenging.[8,11-13] For example, changes in body mass index (BMI), excess weight loss (EWL), and percentage of total weight gained are the variables most often used to measure the amount of WR, but some authors prefer to describe WR simply by observing the absolute weight regained in postsurgical patients.[11,13-15]

Many factors that potentially contribute to WR have been investigated.[3,4,9] Specifically, several studies have investigated whether the presence of a psychiatric comorbidity before and/or after BS could influence weight outcome.[8] One of the major problems of these studies is that they frequently used insufficient weight loss rather than WR as the main defining parameter.[16,17] Previous systematic reviews found no clear evidence that preoperative mental health conditions are associated with differential weight loss results after surgery.[18-20] Although binge eating behaviours before BS have not been associated with poorer outcomes, some authors observed a negative clinical impact of maladaptive eating behaviours, especially grazing and loss of eating control, in the postoperative period.[12-15,21-23] In addition, some evidence suggests that postoperative depressive psychopathology appears to be associated with WR in most studies.[24,25] Finally, one of these reviews suggested that WR was potentially associated with substance use following BS.[26]

Although WR seems to be a frequent outcome of BS,[4] a full understanding of this phenomenon, including its definition, prevalence, risk factors, and clinical significance, is still pending. The aim of this study was to conduct a systematic review and meta-analysis to investigate whether the presence of psychopathology is associated with WR after BS.

2 | METHODS

This systematic review was carried out according to PRISMA guidelines[27] and was registered in Prospero with the number CRD42015023876. Five electronic databases were searched (PubMed, Web of Science, Cochrane Library, Scopus, and PsycINFO), with no restrictions on publication date or language. Additionally, a review of the referenced lists of related systematic reviews and meta-analyses was conducted to search for articles that may have been missed in the initial database search. The database and manual searches were completed by 30 September 2018. The search was conducted independently by two authors (M.P., M.F.M.). Discrepancies were resolved through discussion between the two authors and, when necessary, by a third party (J.C.A.). The search was based on predefined keyword terms (in Appendix S1) with the consultation of a research librarian (D.M.T.P.F.). All papers that did not meet the inclusion criteria were excluded, with reasons provided in Figure 1.

2.1 | Eligibility criteria

Studies that assessed the relationship between psychiatric comorbidity and WR following BS were included in the analysis. The inclusion criteria were the following: (1) clinical samples of adult males or females subjects (≥18 months) who were submitted to any type of weight loss surgical procedure, (2) a minimum follow-up time of more than 18 months after BS for the assessment of WR, and (3) psychopathological assessment that included any type of specific validated instruments (self-report measures, questionnaires, and structured interviews). In addition, case reports and case series were excluded. Papers reporting meta-analysis and systematic reviews were not included, but their references were mechanically searched for studies not found in the electronic search.

2.2 | Study selection and data extraction

First, titles and abstracts were screened by two independent reviewers (M.F.M. and M.P.) using specific inclusion criteria. Full papers were selected for the next phase (full reading) when they fulfilled the inclusion criteria or when the abstract did not present enough information to make an inclusion decision. Reviewers were not blinded to authors, institutions, or journals.

The data were collected from the included studies into a data extracting form (M.F.M.) and were rechecked by another author (M.P.). Information regarding study design, sample size, measurement of WRs, type of psychopathology evaluated, bariatric procedure performed, and additional relevant findings were collected. When additional data information was needed, the authors were contacted and asked for the information.

Psychiatric diagnoses were extracted according to the study conclusions and could be based on nonstructured clinical interviews or supported by an assessment instrument [structured interviews (ex: Structured Clinical Interview for DSM-IV (SCID-IV), Eating Disorder Examination (EDE)) or a validated questionnaire Beck Depression Inventory (BDI), Three-Factor Eating Questionnaire (TFEQ), Body Shape Questionnaire (BSQ)]. WR extraction was based upon how it was reported in the study (change in BMI, kg, percentage, or WR cut-off point).

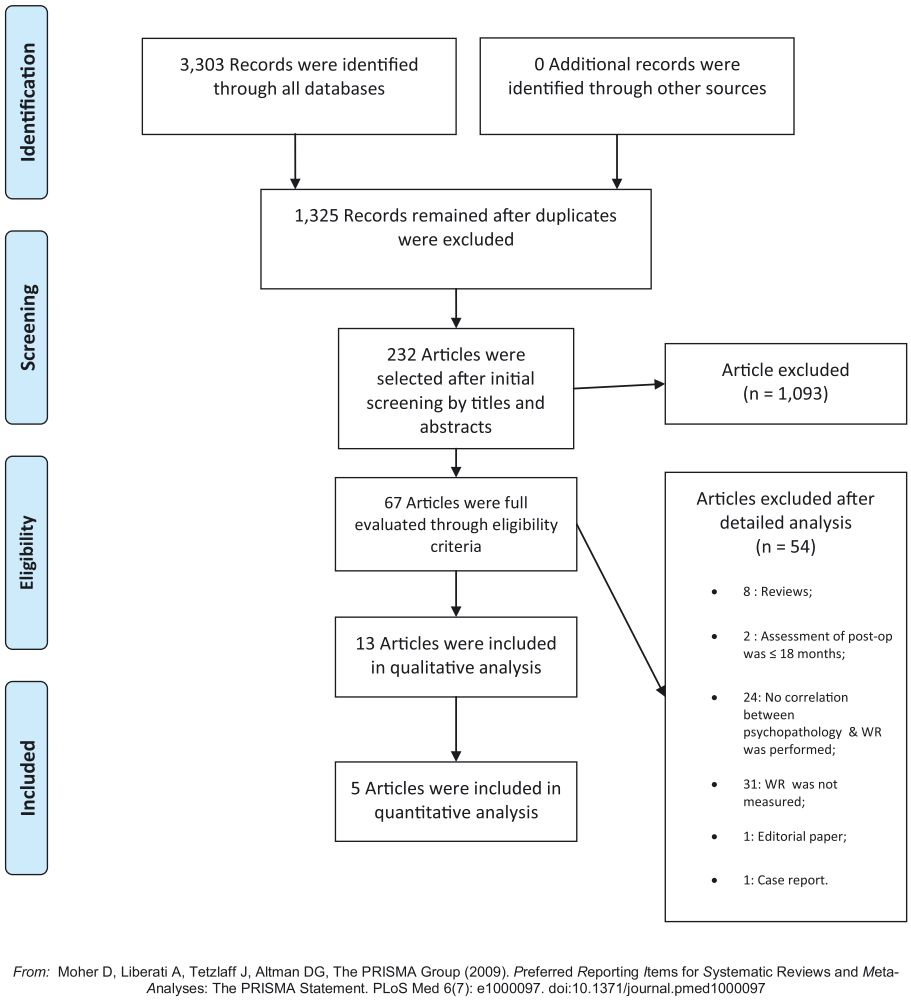


FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 [Colour figure can be viewed at wileyonlinelibrary.com]

2.3 | Quality assessment

Quality of evidence was rated using the Newcastle-Ottawa Quality Assessment Scale (NOS) adapted for cross-sectional studies and NOS for cohort studies,[28] and ratings were defined as "number of stars" in four major categories: study design, sample selection, comparability, and outcomes. Based on this assessment, the studies were classified as poor (0-1), fair (2), or good (≥3). All classifications were determined by consensus among the authors (Table 2).

2.4 | Statistical analysis

The quantitative analysis (meta-analysis) was carried out only for the studies that reported crude data regarding the association between WR and eating or general associated psychopathology. The procedure was conducted when we had information from at least three studies with a particular outcome. The qualitative description was provided for the other studies. The pooled relative risk (RR) was calculated using the random effect model, due to the important heterogeneity evaluated by the statistics I^2 and chi-squared for homogeneity. Heterogeneity is usually categorized at 25% (low), 50% (moderate), and 75% (high).[29]. Sensitivity analysis was used to further explore the impact of specific studies on the heterogeneity. The small number of studies included in the meta-analysis along with the high heterogeneity did not allow the use of funnel plots to assess the risk of publication bias. Meta-regression analysis was tried to explore reasons of heterogeneity, but again, the small number of studies included compromised the appropriate use of this methodological tool.[30] All analyses were carried out using Stata 14.0 (Stata Corporation, College Station, TX, USA).[31]

3 | RESULTS

A total of 3,303 articles were initially screened through database search engines. After excluding duplicates and screening titles and abstracts, 67 manuscripts were considered eligible for a full reading.

After reading all the manuscripts and abstracts, 13 articles were included for the qualitative analysis and 5 of them were considered eligible for the meta-analysis (Figure 1).

3.1 | Study characteristics

The number of participants in the studies ranged from 14 to 497 (total of 1,766), and women were the majority in most of the studies (87.6%), with an average participation rate ranging from 78.3% to 100%. Follow-up time intervals after surgery varied from 18 to 60 months. Across the studies, initial pre-BS BMI was 44.5 to 51.1 (kg/m^2). Seven studies were conducted in the United States, two in Spain, one in Brazil, and four were performed by the same research group in Portugal. WR prevalence ranged from 11.96% to 59.6%. Considering the number of participants submitted to any type of surgery, gastric bypass (1,173/66.8%) was the most common surgical procedure performed, followed by gastric banding (563/32.06%) and sleeve (20/1.13%). Of note, five studies[12-14,24,32] included more than one procedure in the same sample (Table 1).

Heterogeneity between studies was observed regarding the inclusion of variables of interest such as obesity phenotype, ancillary treatments besides surgical procedure, psychosocial factors before and after BS, preexisting psychopathology, and the nature of follow-up. Most of the studies (n = 11) used BMI as the standard parameter of obesity evaluation, and none of those included waist circumference. Also, obesity-related comorbidities were described only in four studies.[14,25,33,34] In addition, only three studies reported any type of complementary treatment including psychotherapy, support group, or nutritional counselling.[33-35] Psychosocial factors such as alcohol use,[14] physical activity,[14,25,34] psychological impairment,[13,24,34] and quality of life[23,25,36] were only evaluated in post-BS period. Finally, although preoperative psychopathology was assessed in seven studies,[14,22,23,25,32-34] only four[22,23,32,33] evaluated it in a structured manner to be included in the analysis. On the other side, postoperative psychopathology was assessed in 12 studies.[12-15,22-25,32,34-36]

Eleven studies were cross-sectional, and two were longitudinal. The definition of WR in these studies had ten different cut-off points, and they employed various measurement units (Table 1). Twelve studies used self-reported validated questionnaires. The Eating Disorder Examination-Questionnaire (EDE-Q) was the most employed eating disorder questionnaire. Of note, EDE interview was also carried out in five of these studies. For general psychopathology, BDI was the most utilized measure across six studies.

Postoperative psychopathology was assessed in 12 studies.[12-15,22-25,32,34-36] In terms of general psychopathology, three studies found a positive association with WR: two studies[24,25] with depression (higher BDI scores) and another[12] with the "attentional impulsivity" domain of Barret Impulsivity Scale (BIS-11). In 10 of the studies that assessed eating related psychopathology, only one study[35] failed to demonstrate a significant difference in post-BS eating psychopathology in groups with or without WR. In nine studies,[12-15,23,32,34,37,38] a positive association between eating psychopathology and WR was reported.

3.2 | WR definition and associated outcomes

WR had different prevalence in studies employing higher WR cut-offs (eg, >10% from nadir weight) compared with studies that defined lower WR cut-offs (eg, >5%, ≥3%, ≥2 kg). Overall, the difference across the studies in WR ranged from 23.7%[35] to 38.33%[25] in studies using higher WR cut-offs, in contrast with 39.3%[32] to 59.6%[38] in studies utilizing lower WR cut-offs.

Several factors were reported impacting WR: pre-BS BMI, postoperative time duration, type of surgical procedure, level of physical activity, and other specific factors analysed in isolated studies. The pre-BS BMI was only evaluated in two studies, being positively associated with WR[13] in one and with none impact at all in another study.[36] Regarding BS features, postoperative time duration was found to be positively associated with WR in five studies.[12,13,34-36] These studies reported that the WR groups exhibited a significantly longer follow-up time from surgery comparing with the non-WR groups after BS.

Differences in surgical procedures (restrictive or malabsorptive) impacting WR were analysed in one study.[12] The authors found different WR prevalence between laparoscopic gastric banding (LAGB) versus laparoscopic Roux-en-Y gastric bypass (LRYGB), 17.7% versus 5.5% ($P < .0001$).

Some of the studies investigated the association between a psychosocial factor and WR. Livhits et al[34] found that low physical activity (OR = 5.51, 95% CI: 1.68-18.02) and low self-stem (OR = 4.07, 95% CI: 1.20-13.83) were associated with WR. However, participation in pre- or post-BS support groups was not associated to WR. In addition, Silva et al[35] observed that a higher post-BS psychological counselling compliance (WR group: 21.1% × non-WR group 50.8%, .02) and a good-quality diet (OR = 0.95, 95% CI: 0.9-0.99) were considered protective factors against WR, but different from the findings of Livhits et al,[34] physical activity did not differ between the WR and the non-WR groups (WR group: 34.4% × non-WR group 26.3%, .58).

3.3 | General psychopathology and WR

Seven studies[12,14,23-25,32,36] evaluated general psychopathology through self-report validated scales, and none of them used structured clinical interviews. Four studies[12,24,25,36] reported analyses of the presence of pregeneral or postgeneral psychopathology with WR. Two studies[24,25] reported a positive association of postoperative depressive symptoms (BDI scores) with WR. One study[12] that assessed impulsivity using the BIS-11 found that only the attentional domain (not the motor or nonplanning domains) was positively associated with WR ($P < .01$).

Health-related quality of life was evaluated in three studies in post-BS period. A higher degree of disability was associated with WR in two studies[12,24] that measured psychological impairment (psychological distress, social performance, interpersonal relationships, quality of life) using the Outcome Questionnaire-45.2 (OQ 45.2). Conceição et al,[12] after controlling WR by time after BS and type of surgery, still found positive association between WR and higher

TABLE 1 Studies investigating the association between general and eating psychopathology with weight regain (WR)

Author, Country, Y	Postop Evaluation Time	Sample (n)	Surgery Procedure	Weight Regain Definition	Instruments	General Psychopathology	Eating Psychopathology	Study quality rating
Cross-sectional studies								
Hsu et al, USA (1997)	≥24 mo	14	Bypass	≥5lb	DSM-IV criteria, EDE	NR	Pre-BS eating disturbance was associated w/ WR (P < .01).	Poor
Kalarchian et al, USA (2002)	≥2 y	96	Bypass	BMI and lb	EDE-Q, TFEQ	NR	WR was higher in the post-BS BE-group compared to the post-BS non-BE group (P < .001).	Poor
Busetto et al, Italy (2005)	>5 y	379	Gastric banding	%EWR ≥20%	DSM-IV criteria	NR	No difference in % of WR between pre-BS BED (20.8%) and pre-BS non-BED (22.5%) patients.	Fair
Kofman et al, USA (2010)	≥3 y	497	Bypass	lb	QEWP-R, M-A, QoLQ	WR >10% EWL was associated w/lower postop quality of life (P < .001)	WR >10%EWL was associated w/post-BS eating psychopathology (.03; P < .001). WR was correlated to post-BS: BE (.006), LOC (P < .001), and grazing (P < .001).	Poor
Livhits et al, USA (2011)	≥2 y	119	Bypass	≥15%	BES, EI	NR	WR post-BS patients had high scores on BES (.014) and on EI disinhibition scores (.013). EI disinhibition post-BS scores remained associated w/WR after control for pre-BS BMI and time for surgery (OR 1.27, 95% CI 1.02-1.57).	Fair
Conceição et al, Portugal (2014)	>24 mo ∞	53	Bypass, gastric banding, sleeve	ΔBMI	EDE, EDE-Q	NR	Post-BS LOC was associated w/higher WR (P < .001). The mean BMI regain of patients w/post-BS LOC was 6.41 ± 3.82.	Poor
Conceição et al, Portugal/USA (2014)	>24 mo ∞	127	Gastric banding, bypass	%EWR >15%	EDE-BSV, EDE-Q, OQ45.2, BDI, BIS-11, ODE, BSQ	WR was associated w/ higher post-BS psychological distress (P < .05) and increased post-BS attentional impulsiveness (P < .01)	WR was associated w/post-BS: P&N (P < .0001) and problematic eating (P < .001).	Fair
Sousa et al, Portugal (2014)	>2 y	52	Bypass, gastric banding, sleeve	>5%	BDI, BSQ, EDE, OQ45.2	WR was correlated to post-BS OQ45.2 (P < .001) and post-BS BDI scores (P < .001)	WR was correlated to post-BS BE episodes and post-BS BSQ scores (P < .001).	Good
Nicolau et al, Spain (2015)	>18 mo	60	Bypass, sleeve	>10%	Grazing[1] BDI	NR	72% of individuals w/post-BS grazing had WR compared with 11.7% of those w/o post-BS grazing (P < .0001).	Fair
Silva et al, Brazil (2016)	≥24 mo	80	Bypass	>10%	TFEQ	NR	Post-BS TFEQ scores did not differ between those w/and w/o WR.	Good

(Continues)

TABLE 1 (Continued)

Author, Country, Y	Postop Evaluation Time	Sample (n)	Surgery Procedure	Weight Regain Definition	Instruments	General Psychopathology	Eating Psychopathology	Study quality rating
Nicolau et al, Spain (2017)	>18 mo	60	Bypass	>10%	BDI	The presence of post-BS BDI scores ≥16 was associated with higher prevalence of WR (70% vs 32%, .024)	NR	Good
Longitudinal studies								
White et al, USA (2010)	24 mo	168	Bypass	≥2 kg	BDI, SF-36, EDE-Q	NR	Pre-BS LOC did not predict WR at 24-mo post-BS. The presence of post-BS LOC at 12-mo post-BS predicted WR at 24-mo post-BS (OR = 2.16; 95% CI: 0.995-4.687).	Good
Conceição et al, Portugal/USA (2017)	2 y	61	Gastric banding, bypass	≥3%	EDE, EDE-Q, BDI	NR	Post-BS LOC and P&N (but not pre-BS) were predictors of WR (OR = 5.01; 95% CI: 1.60-15.99).	Good

Notes. Grazing[1], Saunders et al operationalized definition of grazing; variation; ∞ only data related to individuals with ≥24 months were extracted.

Abbreviations: BDI, Beck Depression Inventory; BE, binge eating; BED, binge eating disorder; BES, binge eating scale; BIS-11, Barret Impulsivity Scale; BMI, body mass index; BMIR, body mass index regain; BS, bariatric surgery; BSI-18, Brief Symptom Inventory-18; BSQ, Body Shape Questionnaire; CI, confidence interval; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders; ED, eating disorders; EDE, Eating Disorder Examination; EDE-BS, Eating Disorder Examination-Bariatric Surgery; EDE-Q, Eating Disorder Examination-Questionnaire; EDNOS, Eating Disorder No Other Specified; EI, eating inventory; EWL, excess weight loss; EWR, excess weight regain; lb, pounds; LOC, loss of control eating; kg, kilograms; M-A QoLQ, Moorehead-Ardelt Quality of Life Questionnaire; NBE, no binge eating; NR, no reported; OBE, objective binge eating; ODE, Obesity Disordered Eating Questionnaire; OQ 45.2, Outcome Questionnaire 45; OR, odds ratio; PBE, problematic eating behaviour; P&N, picking and nibbling; QEWP-R, Questionnaire on Eating and Weight Patterns Revised; SBE, subjective binge eating; SF-36, Short-Form 36; TEFQ, Three-Eating Factor Questionnaire; TWR %, percentage of total weight regain; WR, weight regain.

psychological distress ($P < .05$). Sousa et al[24] reported a positive association between WR and psychological impairment through the total score of OQ 45.2, but did not describe any specific item of the scale in this analysis. Another study[36] reported that health-related quality of life was negatively correlated with WR ($r = -0.35$, $P < .001$) through the Moorehead-Ardelt Quality of Life Questionnaire II (M-A QoLQ) that measured self-esteem, physical well-being, social relationships, work, sexuality, and eating behaviour in post-BS patients. Results are summarized in Table 1. It is important to mention that it was not possible to perform a meta-analysis of the finding regarding WR and general psychopathology because of lack of sufficient data.

3.4 | Eating psychopathology and WR

Twelve studies evaluated eating psychopathology in BS: Two studies investigated the preoperative period,[22,33] eight studies focused on the postoperative period,[12-15,24,34-36] and two studies described preoperative/postoperative eating psychopathology using a longitudinal design.[23,32] Notwithstanding, results were not based on a full-fledged eating disorder diagnosis (eg, binge eating disorder (BED), BN). Indeed, most of the studies reported eating disordered behaviours such as loss of control (LOC), grazing, and binge eating (BE) episodes. Additionally, other maladaptive eating behaviours, not related to psychopathology, such as vomiting, plugging (more associated with gastric banding), and dumping (associated with bypass),[12,25] were described by some authors. In this way, Silva et al[35] found a greater incidence of weekly vomiting (36.8% vs 13.3%, .03) in the WR group compared with the stable weight group. Interestingly, patients were all submitted to gastric bypass, rather than gastric banding.

Among the studies reporting pre-BS eating psychopathology, two studies found a negative association between previous eating psychopathology (LOC, picking and nibbling) and WR,[23,32] one study[22] reported a positive association between the presence of eating disorders (BED and night eating syndrome (NES)) and WR, and one study[33] showed no impact of pre-BS eating disturbances on WR. Of note, Hsu et al[22] reported that 66.7% of individuals with pre-BS eating psychopathology maintained this condition in the post-BS period in comparison with those without eating disturbances.

From the 10 studies[12-15,23,24,32,34-36] that assessed eating-related psychopathology post-BS, 9 studies[12-15,23,24,32,34,36] reported a positive association with WR. Most of the studies did not make any distinction between objective and subjective binge episodes.[15,24,36] Indeed, the presence of LOC was the main feature associated with the definition of a BE episode. One exception was Livhits et al,[34] who classified BE episodes thru BES scores. In addition, the study that has found no association between WR and post-BS eating psychopathology used TFEQ dimensions scores as independent variables.[35] In addition, the two longitudinal studies also reported the persistence of the eating psychopathology in the post-BS period. White et al[23] reported that pre-BS LOC predicted increased psychosocial difficulties and post-BS LOC. In the same line, Conceição et al[32] found patients that exhibited pre-BS LOC were more prone to engage in post-BS grazing. Specifically, WR was positively associated with BE in four studies,[15,24,34,36] grazing in four studies,[14,32,36,39] LOC in five studies,[13,32,36,39,40] and disturbed body image in one study.[24] Results are summarized in Table 1.

3.5 | Quality assessment appraisal

Based on NOS, five studies were classified as good (35.8%), four were considered fair (35.8%), and four were considered with poor quality (28.6%). Considering the NOS items, lower scores were observed in the areas of sample selection (sample size, nonrespondents) and comparability. Results are summarized in Table 2.

3.6 | Meta-analysis of the association between WR and eating psychopathology

Only 5 from the 13 studies presented with adequate crude data information for inclusion in the meta-analysis. Most of the studies presented limited information of the analysis, as the association of WR with psychopathology was part of a secondary outcome. Besides, just three of the authors contacted provided additional data. The five studies[12-14,32,38] included in the meta-analysis compared WR among those with and without eating psychopathology (LOC, grazing). The pooled RR presented in Figure 2 shows an average increase of 2.2 times in the proportion of WR associated with eating psychopathology. The heterogeneity was moderate to high ($I^2 = 69.5\%$), but sensitivity analysis showed that it was caused by one study. When Nicolau et al[14] was excluded, the statistic I^2 dropped to 7%, and the RR was reduced to 1.85 (95% CI: 1.54-2.21) but was still statistically significant.

We could not formally explore reasons for this heterogeneity, as the proportion of women or the type of BS procedure did not allow the use of subgroup analysis or meta-regression. Regarding the proportion of women in the sample, the numbers were very similar among the studies. This lack of variance along with the small number of studies did not allow the use of these statistical tools. In relation to the impact of the type of surgery on the WR, the only technique that showed enough variability among the studies to allow the use of meta-regression was the gastric bypass. Nevertheless, the meta-regression did not find a statistically significant association between the proportion of this procedure in each study and the magnitude of the association with WR ($\beta = 0.007$; .42). Again, the small number of studies might have compromised this analysis. One possible explanation for this difference to be taken into consideration might be the fact that the other four studies[12,13,24,32] of five studies were carried out by the same research group and had approximated equal methodology. The presence of eating related psychopathology was associated with WR with a pooled OR of 8.86 (OR = 2.2, 95% CI 1.54-3.15) (Figure 2).

4 | DISCUSSION

This review is a meta-analysis investigating the potential association of general and eating-related psychopathology with WR in BS patients.

TABLE 2 Results of the critical appraisal of the included studies

Newcastle-Ottawa Scale Adapted for Cross-Sectional Studies

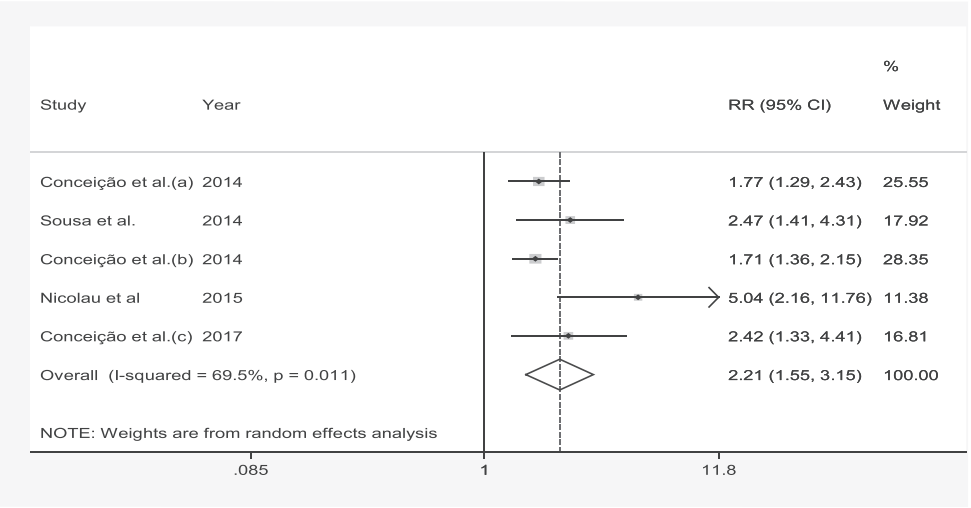
Author, Country, Y	Study Design	Selection				Comparability	Outcome		AHRQ Standards
		Representativeness of the Sample (1)	Sample Size (2)	Nonrespondents (3)	Ascertainment of the Exposure (Risk Factor) (4)		Assessment of the Outcome (1)	Statistical Test (2)	
Busetto et al, Italy (2005)	Cross-sectional	*			**	*	**	*	Fair (S:3; C:1; O:3)
Conceição et al, Portugal (2014)	Cross-sectional	*			**		**	*	Poor (S:3; C:0; O:3)
Conceição et al, Portugal/USA (2014)	Cross-sectional	*			*	*	**	*	Fair (S:2; C1; O:3)
Hsu et al, USA (1997)	Cross-sectional				**		**	*	Poor (S:2; C:0; O:3)
Livhits et al, USA (2011)	Cross-sectional	*			**	*	**	*	Fair (S:3; C:1; O:3)
Kalarchian et al, USA (2002)	Cross-sectional	*			**		*	*	Poor (S:3; C:0; O:2)
Kofman et al, USA (2010)	Cross-sectional	*			**		*	*	Poor (S:3; C:0; O:2)
Nicolau et al, Spain (2015)	Cross-sectional	*			**	*	*	*	Fair (S:3; C:1; O:2)
Nicolau et al, Spain (2017)	Cross-sectional	*			**	**	**	*	Good (S:3; C:2; O:3)
Sousa et al, Portugal (2014)	Cross-sectional	*			**	**	**	*	Good (S:3; C:2; O:3)
da Silva et al, Brazil (2016)	Cross-sectional	*			**	**	**	*	Good (S:3; C:2; O:3)

Newcastle-Ottawa Scale for Cohort Studies

Author, Country, Y	Study Design	Selection				Comparability	Outcome			AHRQ Standards
		Representativeness of the Exposed Cohort (1)	Selection of the Nonexposed Cohort (2)	Ascertainment of Exposure (3)	Outcome of Interest Was not Present at Start of Study (4)	Comparability of Cohorts	Assessment of Outcome (1)	Was Follow-Up Long Enough for Outcomes to Occur (2)	Adequacy of Follow-Up of Cohorts (3)	
Conceição et al, Portugal/USA (2017)	Prospective cohort	*	*	*	*	**	*	*		Good (S:4; C:2; O:2)
White et al, USA (2010)	Prospective cohort	*	*	*	*	**	**	*		Good (S:4; C:2; O:3)

Notes. Selection (S): (1) all subjects or random sampling (*) or nonrandom sampling (*); selected group of users () or no description of the sampling strategy ( ); (2) justified and satisfactory (*) or not justified ( ); (3) comparability between respondents and nonrespondent characteristics is established, and the response rate is satisfactory (*) or unsatisfactory ( ); no description ( ); (4) validated measurement tool (**), nonvalidated measurement tool, but the tool is available or described (*) or no description of the measurement tool ( ); comparability (C): the study controls for the most important factor (select one) (*) or the study control for any additional factor (*); outcome (O): (1) independent blind assessment (**), record linkage (**), self-report (*), no description (); (2) clearly described and appropriate (*), not described or incomplete (). Agency for Healthcare Research and Quality (AHRQ) criteria thresholds for converting Newcastle-Ottawa Scales, quality rating by quantifying "stars": good (points in selection domain ≥3 + points in comparability domain ≥2 + points in outcome domain ≥2); fair (points in selection domain = 2 + points in comparability domain ≥1 + points in outcome domain ≥2); poor (points in selection domain 0-1 + points in comparability domain 0 + points in outcome domain 0-1).

Notes. Selection (S): (1) truly representative (*), somewhat representative (*), selected group of users (), no description ( ); (2) drawn from the same community as the exposed cohort (*), drawn from a different source (), no description ( ); (3) secure record (*), structured interview (*), written self-report ( ), no description ( ); (4) yes (*) or no ( ); comparability (C): select the most important factor (*), control for a second important factor (*); outcome (O): (1) independent blind assessment (*), record linkage (*), self-report ( ), no description (); (2) yes (*) or no (); (3) complete follow-up (*), subjects lost to follow-up unlikely to introduce bias (*), no description of those lost (), no statement (). Agency for Healthcare Research and Quality (AHRQ) criteria thresholds for converting Newcastle-Ottawa Scales, quality rating by quantifying "stars": good (points in selection domain ≥3 + points in comparability domain ≥2 + points in outcome domain ≥2); fair (points in selection domain = 2 + points in comparability domain ≥1 + points in outcome domain ≥2); poor (points in selection domain 0-1 + points in comparability domain 0 + points in outcome domain 0-1).



Conceição et al (a)[13] , Souza et a[24], Conceição et al (b)[12] , Nicolau et al [14], Conceição et al (c) [32]

13. Conceicao E, Bastos AP, Brandao I, et al. Loss of control eating and weight outcomes after bariatric surgery: a study with a Portuguese sample. *Eat Weight Disord.* 2014;19(1):103-109.
24. Sousa P, Bastos AP, Venancio C, et al. [Understanding depressive symptoms after bariatric surgery: the role of weight, eating and body image]. *Acta Med Port.* 2014;27(4):450-457.
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FIGURE 2 Forest plot of studies included to meta-analysis for odds ratio (OR) of eating psychopathology in the weight regain (WR) group. Conceição et al (a),[13] Souza et al,[24] Conceição et al (b),[12] Nicolau et al,[14] Conceição et al (c)[32]

As opposed to others, the current review used more restrictive inclusion criteria, with a minimum follow-up time from the bariatric procedure over 18 months. In addition, only studies that used validated instruments for the assessment of psychopathology were included. Our findings suggested a positive association between post-BS eating psychopathology (grazing, LOC, BE) and WR. In a meta-analysis, we found a larger pooled effect size (ORs between 1.70 and 5.04) for WR between those who exhibited eating-related psychopathology (OR = 2.2, 95% CI 1.54-3.15). Conversely, the evidence regarding the association of general psychopathology and WR are less robust, with results exhibiting a positive association between post-BS general psychopathology (depressive symptoms, attentional impulsiveness, and impaired health-related quality of life).

In reviewing the literature published since the initial work of Hsu,[41] disturbed eating behaviours (especially BE) have been consistently associated with BS weight unfavourable outcomes. Previous studies[41-45] showed that BS impacted on the amount of food consumed during a binge episode, primarily due to surgical restriction of gastric volume and some physiological changes (attributed to vagal and hypothalamic signalling, gut peptides, etc). In this way, BE episodes after BS are distinct from those experienced by individuals not submitted to obesity surgery, as the quantitative aspect of BE seems to be significantly small.[43,46] In this perspective, it was suggested that LOC of eating[47] would be a more accurate marker of BE among people who have undergone BS than the amount of food eaten. Moreover, patients submitted to BS could be more prompt to other forms of eating-disordered behaviour such as grazing (distracted, repeated, and nonplanned eating).[48] In fact, most of the studies investigating the relationship between ED and WR included these dimensional forms of eating psychopathology.[12,14,23,46] In a general way, screening for different forms of maladaptive eating behaviours, other than full ED diagnosis, seems more specific related to post-BS evaluation.

The biological mechanisms involved in the interplay between WR and post-BS eating psychopathology are still unknown.[49-51] However, several hypothetical mechanisms could play a potential role in these interactions. First, neurohormonal changes after BS such as the increase in glucagon-like peptide-1 and peptide YY after BS procedure

has an impact on satiety and hunger signals which could impact in post-BS eating psychopathological symptoms.[49] Also, the BS procedure has an influence in reward system leading to a decrease in the preference for palatable foods in post-BS patients.[50,52,53] In this line, disturbances in the reward system are considered currently an essential aspect of eating disorder neurobiology.[54] Thus, this change in the reward circuits after the BS procedure could be involved in the manifestation of eating psychopathology after BS procedure. At least, some authors have considered that genetic polymorphisms (melanocortin-4 receptor gene) are associated with some eating behaviour phenotypes (LOC eating and BE episodes) and could predict weight outcome in the BS population.[51] Although these are potential explanations for the interaction between eating psychopathology and WR in the post-BS period, further investigation on these mechanisms is needed.

Few studies addressed the impact of general psychopathology on WR.[9] Similar to our findings, another review[9] reported that post-BS depression was associated to WR. However, different aspects of impulsive behaviour were included in both reviews. One study in our review found a negative correlation between attentional domain scores on BIS-11 and WR.[12] Meanwhile, the previous review reported an association between disinhibition scores on EDI and WR. In fact, different domains of impulsivity had been linked to obesity development.[55-57] Nevertheless, there are conflicting results in this area, and further investigation of impulsivity in patients submitted to BS and its possible relationship to WR must be done.[58,59]

There has been increasing concern regarding the risks of alcohol and substance use after BS, including its impact on WR.[26] In another review,[26] post-BS problematic alcohol use was positively correlated with WR (.012).[8] In addition, there was higher concerns of anyone about the individual's alcohol use between patients with WR (OR = 12.74, $P < .01$).[60] However, due to failure to fulfil inclusion criteria (minimum follow-up from BS and use of validated instruments), none of these studies were included in our analysis.[8,60] As a matter of fact, alcohol use problems after BS are more predictable to occur by 2 years after BS.[61] Regarding to substance use, however, there is a scant literature with investigations between this psychopathology and WR.

Suicidality has been found across BS literature.[62-65] Some investigators observed higher suicide risk up to a 24-fold increase in BS subjects comparing with general population in a recent study. Several mechanisms are discussed to be involved in this association, including psychiatric comorbidity, psychosocial aspects, and even physiological changes after BS.[62] Additionally, frustration related to failure of expected weight loss and WR could play a role in suicidality.[63] Nevertheless, we are not aware of studies that evaluated specifically the association between suicide risk and WR after BS.

Although our review focused on the relationship between psychopathology and WR, it must be outlined that WR after BS has a multifactorial nature.[9,60,66] Factors related to obesity phenotype, genetics, surgical techniques, psychosocial factors, and individual compliance with follow-up treatment could also impact on BS outcome.[66] Although sleeve gastrectomy has been widely increasing in the last decade, some evidences suggest a higher risk of WR compared with gastric bypass.[67,68] The residual sleeve size and/or ghrelin levels after the procedure could influence food intake and risk of WR.[68] In addition, environmental factors such as diet recommendation adherence and lifestyle changes may also play an important role in weight trajectory after BS.[7,9]

We observed a lack of uniformity in reporting of WR in the studies included in our review. Even across studies from the same research group, different definitions of WR were applied.[12,13,24,32] This discrepancy was reflected in the variability of WR reported. We found rates of WR ranging from 20.8% to 100% in patients with psychiatric comorbidity and between 5% and 30.4% in the subset without psychiatric comorbidity. In addition, the use of different parameters to define WR could have impacted on the interpretation of results in our review. Recently, a prospective cohort of 2,458 adults followed for 6 or 7 years after BS (Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) study) investigated the relationship of different WR definitions with clinical variables. They found that a cut-off of 20% or greater WR, measured from the minimum weight nadir after BS, was best correlated to mental health measures such as quality of life and satisfaction with surgery.[69] In this way, it seems important to develop a consensus regarding WR definition.

This review included a quality appraisal of the studies. Most of the studies were observational, and only two were longitudinal,[23,32] which imposed a difficulty in establishing the relationship between psychopathology and WR. Of note, almost one-third of the studies were classified as poor quality (28.6%) according to NOS. Selection thru internet surveys[34,36] and mailed packages,[15] the lack of sample size calculation and comparability between respondents and nonrespondents were some of the major problems observed. Nevertheless, as defined by our inclusion criteria, the use of validated instruments in the studies in this review may have strengthen our findings comparing with previous reviews.

5 | CONCLUSION

In this review, we found that post-BS eating psychopathology seems to play an important role in WR. Findings regarding post-BS general psychopathology were limited. In contrast, neither pre-BS general nor eating psychopathology predicted WR. Nevertheless, future studies need to address some potential bias including the use of larger samples, WR standardized definition, structured assessment, and the use of a longitudinal design to better understand how mental health could impact on long-term weight variation in BS. Notwithstanding these limitations, this is the first review to pool data for BS and WR in relation to psychiatric comorbidity.

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CONFLICT OF INTEREST

Jose C. Appolinario receives/has received research grants, consultancy fees, and advisory board fees from Shire Pharmaceuticals. Walmir Coutinho reports receiving lecture fees from Abbott Diabetes Care, Janssen, Germed, and Novo Nordisk; serving on advisory boards for Abbott Diabetes Care, Germed, EMS, and Novo Nordisk; and receiving travel reimbursement from Abbott Diabetes Care, Janssen, Novo Nordisk, Germed, and EMS.

AUTHOR CONTRIBUTIONS

Conception and design of the protocol: Mauro, Brasil, Carneiro, Coutinho, Coutinho, and Appolinario. *Data collection*: Mauro, Papelbaum, and Appolinario. *Data analysis and interpretation*: Mauro, Papelbaum, Freire Coutinho, and Appolinario. *Data interpretation*: W, Coutinho. *Critical revision of the paper*: Papelbaum, Brasil, Carneiro, Coutinho, and Coutinho. *Final approval of the version to be published*: Papelbaum, Brasil, Carneiro, Coutinho, and Coutinho. *Draft the article*: Mauro and Appolinario.

ORCID

Maria Francisca F.P. Mauro https://orcid.org/0000-0003-4702-3915

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SUPPORTING INFORMATION

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

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