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REVIEW

Does Exercise Improve Weight Loss after Bariatric Surgery? A Systematic Review

Kristine Egberts · Wendy A. Brown · Leah Brennan · Paul E. O'Brien

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Abstract Bariatric surgery leads to significant weight loss in the obese patient. Exercise has been shown to improve weight loss and body composition in non-surgical weight loss programmes. The role of exercise to improve weight loss following bariatric surgery is unclear. The objective of this review is to systematically appraise the evidence regarding exercise for weight loss in the treatment of obesity in bariatric surgery patients. MEDLINE, AMED, CINAHL, EBM Reviews (Cochrane Database, Cochrane Clinical Trials Register) were searched, obesity-related journals were hand-searched and reference lists checked. Studies containing post-surgical patients and exercise were included with the primary outcome of interest being weight loss. A literature search identified 17 publications exploring exercise in bariatric surgery patients. All studies were observational; there were no intervention studies found. The most commonly used instruments to measure activity level were questionnaires followed by telephone interview, surgeon reporting and clinical notes. There was a positive relationship between increased exercise and weight loss after surgery in 15 studies. Meta-analysis demonstrated in patients participating in exercise a standardised mean of 3.62 kg (CI=1.28, 5.96) greater weight loss compared to the minimal exercise groups. Observational studies suggest that exercise is associated with greater weight loss following bariatric surgery. Randomised controlled trials are required to further examine this relationship.

Keywords Laparoscopic adjustable gastric banding · Surgery · Exercise · Weight loss

K. Egberts (✉) · W. A. Brown · L. Brennan · P. E. O'Brien
Centre for Obesity Research and Education (CORE),
School of Public Health & Preventive Medicine,
Monash University,
The Alfred Centre, Commercial Road,
Melbourne, Australia
e-mail: Kristine.Egberts@monash.edu

Introduction

Bariatric surgical procedures generate substantial weight loss primarily by reducing energy availability through decreased intake and/or reduced absorption of macronutrients. Studies of non-surgical weight loss have confirmed that improved weight loss outcomes can be achieved when an exercise programme is combined with reduced energy intake, compared with reduced intake alone [1–4].

A Cochrane systematic review of 43 non-surgical weight loss studies found that diet plus regular exercise was associated with modest improvement of weight loss (1 kg—95% CI of 0.7–1.3) compared to diet alone. Further, increased intensity of exercise was associated with a greater weight loss (1.5 kg—95% CI of 0.7–2.3) [5].

It seems intuitive that exercise should benefit the post-bariatric surgery patient in several ways. Total daily energy expenditure is the sum of resting energy expenditure (REE), the thermic effects of food and the thermic effects of activity [6]. The most obvious primary role of exercise is to increase the thermic effect of activity. A 30-min period of moderate intensity exercise, such as brisk walking, is estimated to use 150–300 kcal depending on body weight [7]. This would represent an average of 20% of energy intake in a typical post-weight loss surgery patient [8].

Second, in any weight loss programme, it is important to focus on fat loss while maintaining the fat-free mass as the muscle component is responsible for the majority of the REE. The REE accounts for 60–70% of total energy expenditure, so the loss of muscle mass that inevitably accompanies any weight loss has a negative influence on energy balance. A recent systematic review shows that the loss of fat-free mass was a significant component of weight loss for all bariatric procedures and that the extent of loss varies for the different procedures [9]. Biliopancreatic diversion was associated with 26%, Roux en Y gastric bypass 31% and laparoscopic adjustable gastric banding 18% loss of fat-free mass [10]. Mitigation of this loss of muscle through exercise should lead to a more favourable outcome in terms of body composition.

The aim of this study is to systematically review the evidence regarding the impact of exercise on weight loss following bariatric surgery, to determine if exercise facilitates optimal post-surgical weight loss.

Materials and Methods

Literature Search

A systematic search of relevant medical databases for full-text original articles relating to the above criteria was performed. Databases included MEDLINE, AMED, CINAHL, EBM Reviews (Cochrane Database, Cochrane Clinical Trials Register). The journals Obesity Surgery and Surgery for Obesity and Related Disorders (SOARD) were hand-searched. The reference lists of these included studies were also searched.

Article Inclusion Criteria

Inclusion criteria for this review included (1) all published clinical or observational studies of exercise in people with obesity were considered for inclusion; (2) adults (age 18–60) with obesity according to body mass index, waist circumference or waist-to-hip ratio AND bariatric surgery patients (all types); (3) the studies included reports on exercise defined as 'any form of physical activity performed on a repeated basis for a defined period of time', or appropriate score on a physical activity questionnaire (4) outcome variables included weight or another indicator of body mass [e.g. %EWL, body mass index (BMI), waist measurement, waist-to-hip ratio]; (5) where exercise activity, frequency and/or intensity was reported as the main outcome; (6) where study length was greater than 2 months. In the case of more than one publication arising from the same study or patient population, the largest study only was considered.

The following data were abstracted from each study: study design, type of operation, baseline patient demographics, number of patients and type of physical activity or exercise, and degree of post-operative weight loss. The methodological quality of all studies was independently assessed by the reviewer using established criteria [11, 12].

Statistical Analysis

The key outcome of interest was weight loss measured as weight lost in kilograms. From the pooled data, the mean weight loss was calculated. Patients were stratified according to their level of observed activity and differences in weight loss were calculated. A standardised mean difference was calculated. The pooled standardised mean difference was computed using a random-effects model (forest plot). Statistical heterogeneity was tested by applying the I^2 statistic. Analysis of outcomes was performed on STATA (STATA 11, StataCorp Inc 2010) and RevMan (ReviewManager, version 5.0, The Nordic Cochrane Centre 2009). Results are reported as mean±standard deviation and a p value of less than 0.05 was considered significant.

Results

One hundred and ten papers matching the search criteria were found in the initial literature search. The abstracts of these publications were screened and 23 meeting inclusion criteria were obtained in full. Six articles were then excluded for reasons stated in Fig. 1 and 17 papers were included in the final review. Four of these were included in the weight loss meta-analysis. This process including reasons for exclusion is detailed in Fig. 1.

Characteristics of Included Studies

Included studies are described in Table 1. All studies focussed on LAGB or RYGB patients. Study designs were all observational and were either prospective or retrospective cohort studies. No randomised controlled trials or intervention studies were identified.

Included studies reported data on 3,852 patients. The mean number of patients within each study ranged from 30 to 172 (M=157, SD=217) and years to follow-up ranged from 0.5 to 4.5 years (M=1.82, SD=0.94). Study characteristics are shown in Table 1.

Measurement of Exercise

Exercise was measured using one or more of the following questionnaires: the Baecke Physical Activity Questionnaire [13], the International Physical Activity Questionnaire [14],

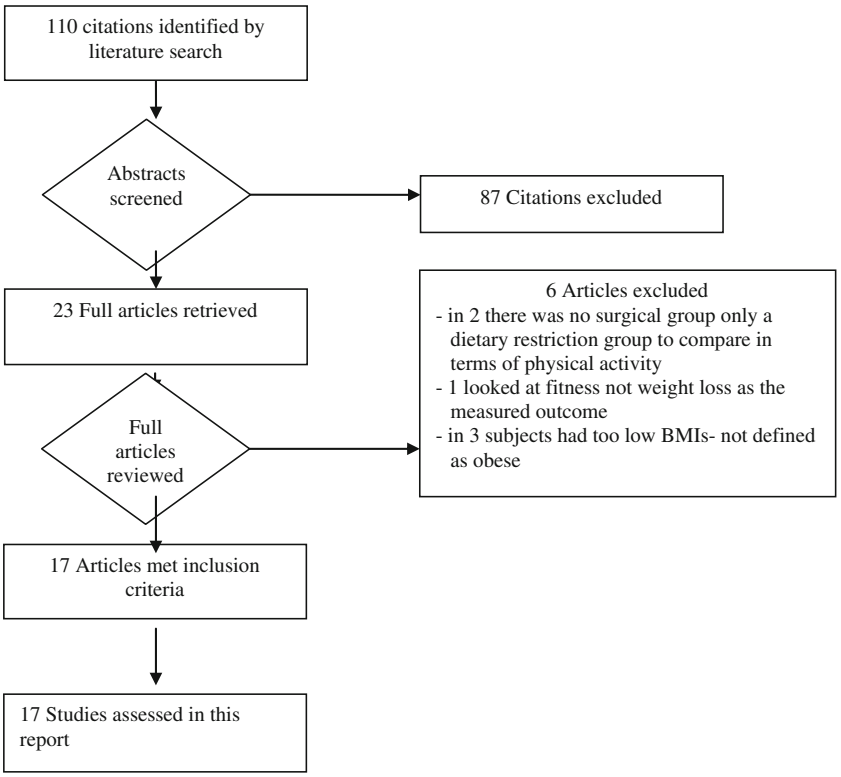

Fig. 1 Flow chart of inclusion of studies

the physical component of the Medical Outcomes trust short form SF-36 [15] or the Physical Activity Belief Questionnaire [16].

These questionnaires were delivered to patients via mail, during consultations, or telephone interviews (see Table 1). These self-assessments produced scores relating to estimates of exercise activity.

Included Studies

In 2009, Josbeno et al. [17] conducted an observational study of 40 post-bariatric patients. They used both the SF-36 questionnaire and a pulse rate monitor armband to explore patient exercise profiles. They measured patients 2–5 years post-surgery to determine if percent excess weight loss was associated with moderate-to-vigorous intensity exercise. They found a significantly greater weight loss in patients who exercised greater than 150 min per week (68.2±19% EWL, $p=0.01$) than those participating in less than 150 min (52.5±17.4% EWL). They also found the level of exercise activity was not associated with physical function, suggesting patients' physical limitations may not be a significant barrier to participation in exercise.

Livhits et al. [18] studied behavioural predictors of weight loss in 148 patients after gastric bypass. This was a retrospective survey of patients who had achieved greater than or equal to 50% EWL at an average of 40 months post-surgery. This group found exercise was significantly associated with successful weight loss (OR 3.5, $p<0.01$) using the SF-36 questionnaire to determine exercise activity.

A study by Chevallier et al. [19] in 2007 focussed on predictors of weight loss success in all patients registered nationally with a medical insurance service at 2 years post-surgery. They studied 1,236 gastric banded patients. Consistent with the literature, Chevallier defined success as >50% excess weight loss. Using logistic regression they found that exercise significantly predicted weight loss ($p<0.001$). They also found that patients who decreased their physical activity after surgery had a 2.3 times higher risk of being unsuccessful in their weight loss.

Latner et al. [20] examined the relationship between post-operative exercise (among other psychosocial and health-related variables) and weight outcomes in gastric bypass patients. Their 2004 study involved semi-structured telephone interviews of 65 women at an average 16 months after surgery. Latner found post-operative exercise predicted greater BMI loss. They also found on an individual level exercise frequency tended to increase after surgery.

Bond et al. [21] used the International Physical Activity Questionnaire (IPAQ) to measure exercise activity after RYGB surgery to determine whether post-operative increases in exercise were associated with better weight loss. They studied 199 patients at 1 year post-op, finding that patients who participated in exercise post-operatively achieved greater weight loss (52.5±15.4 kg) than those who

Table 1 Key characteristics of included studies [17–31]

Author	Intervention details	Definition of exercise	Patients	Duration	Results
Cook	Baecke Physical Activity Questionnaire	A minimum of self-administered 40 min four times per week	RYGB $n=100$	3 years	• Exercisers: good weight loss, no weight regain • Non-exercisers: average of 25.5 kg regained
Metcalf	Baecke Physical Activity Questionnaire +Physical Activity Belief Questionnaire	Any exercise	LAGB patients $n=100$	18 months	• No difference in weight loss between exercising and non-exercising groups • Exercisers: 28% greater loss of fat mass, 8% higher gain in lean body mass, compared to non-exercisers
Buddeberg-Fischer	Telephone interview Baecke Physical Activity Questionnaire +Physical Activity Belief Questionnaire	Any exercise	Both types $n=93$	4.5 years	• Exercisers: 52.8% excess weight loss
Carrasco	Baecke Physical Activity Questionnaire +Physical Activity Belief Questionnaire	Any exercise	RYGB $n=31$	6 months	• Physical activity level was found to be positively correlated to successful weight loss
Chuang	Telephone interview Baecke Physical Activity Questionnaire	Any exercise—including incidental exercise at home and at work	RYGB $n=53$		• Exercisers: higher excess weight loss
Das	Questionnaires focussed on predictors of weight loss	Any exercise	LAGB $n=30$	2 years	• Physical activity level was found to be positively correlated to successful weight loss
Pontiroli	Telephone interview (self-reported exercise)	Any exercise	LAGB patients $n=172$	2 years	• Exercise important to maintain weight • BMI, compliance and percentage of attendance at scheduled exercise education sessions were all associated with weight loss and improved health outcomes up to 2 years
Larsen	Baecke Physical Activity Questionnaire +Physical Activity Belief Questionnaire	Any exercise	RYGB $n=157$	2 years	• No association between exercise and weight outcome
Bueter	SF-36 questionnaire	Any exercise	RYGB $n=85$	27 months	• Positive association between successful post-op weight loss and post-op level of exercise
Bond	International Physical Activity Questionnaire (IPAQ)	Any exercise	RYGB $n=122$	1 year	• Positive association between successful post-op weight loss and post-op level of exercise
Chevallier	Baecke Physical Activity Questionnaire	Any exercise	LAGB $n=922$	1 year	• Post-op physical activity and chance of >50% excess weight loss (OR 2.3)
Latner	Baecke Physical Activity Questionnaire	Any exercise	RYGB $n=65$	16 months	• Positive association between lower BMI and higher post-op exercise • Increase in exercise activity from 0.7 to 2.8 sessions per week
Wolfe	SF-36 questionnaire	Any exercise	RYGB $n=194$	20 months	• Positive association between lower BMI and higher post-op exercise ($r=0.36$, $p<0.01$)
Silver	SF-36 questionnaire Behavioral Risk Factor Surveillance System (BRFSS) questionnaire	Any exercise	RYGB $n=140$	2 years	• Association between duration of post-op exercise and post-op BMI (OR$=-0.15$, $p<0.01$)
Colles	Baecke Physical Activity Questionnaire +Physical Component of Medical Outcomes trust short form SF-36	Any exercise	LAGB $n=127$	1 year	• Physical activity level was found to be positively correlated to successful weight loss

Table 1 (continued)

Author	Intervention details	Definition of exercise	Patients	Duration	Results
					• Baecke Sports Index correlated to %EWL and dietary restraint, and negatively to energy intake, hunger and perceived barriers to exercise
Livhits	SF-36 questionnaire	Any exercise	RYGB n=148	1.5 years	• Exercise significantly associated with successful weight loss (OR 3.5, p<0.01)
Josbeno	SF-36 questionnaire and a pulse rate monitor armband	Any exercise	LAGB n=40	2–5 years	• Significant relationship in patients who exercised greater than 150 min per week (68.2±19% EWL, p=0.01) than those participating in less than 150 min (52.5±17.4% EWL)

RYGB Roux-en-Y gastric bypass, *LAGB* laparoscopic adjustable gastric banding

did not (46.4±12.8 kg). This was also reflected in BMI units lost (post-op exercisers=18.9±4.6 vs. non-exercisers=16.9±4.2 kg/m^2). Exercisers also reported greater general health, vitality and mental health (p<0.01) than non-exercisers, as measured by the Medical Outcomes Study Short Form-36 (SF-36).

The 2006 study by Silver et al. [22] looked at self-reported weight management, dietary and physical activity behaviours in 140 RYGB patients at an average of 2 years after surgery. Silver used the Behavioral Risk Factor Surveillance System (BRFSS) questionnaire. The authors found exercise was a significant predictor of BMI after surgery, and the percentage of patients who reported participating in moderate exercise (average 54.7±38.5 min/session) increased from pre- to post-surgery, from 17.9% to 82.9%.

Cook et al. [23] surveyed 100 gastric bypass patients regarding their eating, drinking, sleeping, exercise and personal habits in the first post-operative year and found exercise was a significant predictor of weight loss success after surgery.

Colles et al. [8] investigated change in exercise activity in 129 LAGB patients 12 months after surgery using the Short Form-36 and the Baecke Physical Activity Questionnaire. This group noted average leisure time and sport-related physical activity scores increased significantly (p< 0.001) and that physical activity was an independent predictors of weight loss (p=0.010).

Two of the 16 studies found no association between exercise and %EWL. Carrasco [27] examined predictors of weight loss success in 31 RYGB patients, 6 months after surgery. In a similar study of 199 LAGB patients, Larsen et al. [31] found exercise was related to mental health but not to BMI reduction or physical health. They used a variety of questionnaires to gather data: the Short Form-36 (SF-36) physical component summary score, the Sport Index of the Baecke Questionnaire (BAQ) and the Physical Exercise Belief Questionnaire (PEBQ).

In summary, 16 of 18 studies (89%) describe a positive correlation between exercise and weight loss. Two studies did not find a correlation. The quality of all studies was low.

Meta-analysis

It was not possible to compare across all studies due to the differences in measures of exercise participation. Data were pooled for weight loss from four studies [23, 24, 27, 29]. To allow for comparisons across these studies, participants

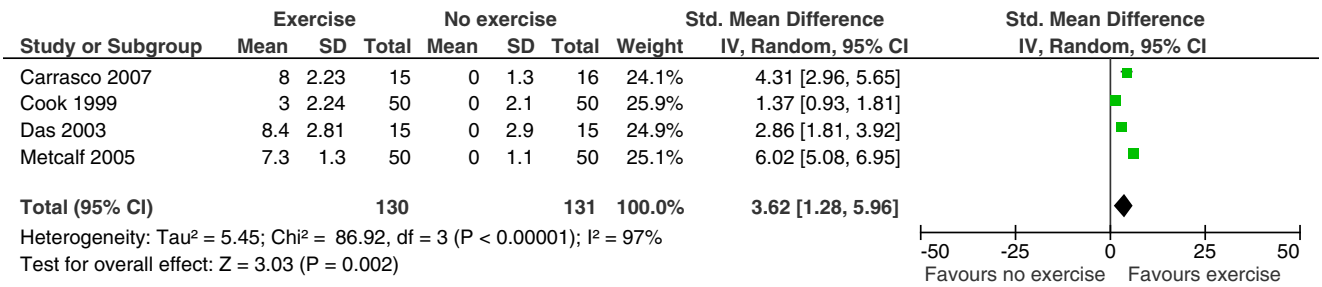

Fig. 2 Forest plot of standardised mean difference at 6 months for weight loss (kg) in exercising and non-exercising patients

were categorised as exercisers or non-exercisers. To be classified as an exerciser, a participant's level of exercise had to be equivalent or greater than national recommendations [a minimum of 30 min per day, totalling at least 150 min per week, American College of Sports Medicine (ACSM)] [11]. Figure 2 shows a forest plot for weight loss in exercising and non-exercising patients from the four eligible studies. There was a positive effect from exercise on weight loss [standardised mean difference (SMD) −3.62 kg (95% CI=1.28, 5.96), $p<0.002$].

Discussion

The primary finding from this systematic review is that increasing exercise participation after bariatric surgery has a positive effect on weight loss. The studies indicate weight loss is greater in those patients who exercised compared to those who did not. This value was found to be a mean of 3.6 kg, which is higher than the 1.5 kg found in a similar meta-analysis of non-surgical weight loss programmes conducted as a Cochrane review in 2006 [5].

It is important to acknowledge the limitations of a review examining a collection of largely heterogeneous studies. All studies used reported exercise as an outcome. Procurement of data in this way may lead to overestimation of exercise participation [28]. All studies reported patient's self-motivated activity and no information was collected on the dietary intake/choices of any participant. It is highly probable that those patients who chose to exercise more were also more motivated to comply with the post-operative dietary programme than the non-exercisers.

In addition, the examined studies were short term and observational in nature. Ideally, a randomised controlled trial (RCT) design is required to elicit the true effect of exercise—in groups with identical selection, recruitment, exercise prescription and outcome measures—on surgical outcomes. In a RCT, exercise could be monitored objectively and outcomes reported consistently.

While the review gives support to the application of exercise as a part of the aftercare of the bariatric surgical patient, the intensity, duration and optimal type of exercise remain to be established. The current recommendations for exercise, derived from an extensive review of data pertaining to non-surgical patients by the American College of Sports Medicine (ACSM), suggest a minimum of 30 min per day, totalling at least 150 min per week [7]. However, the ACSM proposes that 60 min of moderate intensity exercise for at least 5 days per week, thus providing 300 min of exercise per week, is needed to achieve substantial weight loss. It would seem logical that a similar recommendation should be applied to the bariatric surgical patient pending better data.

Another important consideration is post-operative protein intake. During rapid post-surgical weight loss, loss of muscle mass often occurs. A patient's nutritional status needs to be monitored to ensure adequate protein and nutrient intake. This combined with exercise will help prevent wasting of lean body mass and contribute to optimal weight loss outcomes [32].

Future studies should be directed at examining the optimal prescription (duration, intensity and frequency) and type (aerobic or resistance or a combination of the two) of exercise for weight loss in surgical patients. In our Australian group in Melbourne, we have not formally measured exercise through the general process of care, but we are completing an RCT of intense versus standard exercise after gastric banding which will be published in the near future and will include measures of co-morbidity effects.

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Dr Wendy Brown received an Honorarium from Allergan to attend a Surgical Advisory Panel in London in 2009.
Dr Paul O'Brien has written a patient information book entitled 'The Lap-Band Solution: A Partnership for Weight Loss' which is given to patients without charge but some are sold to surgeons and others for which he receives a royalty. He is employed as the National Medical Director for the American Institute of Gastric Banding, a multicentre facility, based in Dallas, Texas, that treats obesity predominantly by gastric banding.

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