Review Article

Prehabilitation in metabolic and bariatric surgery: a narrative review

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Background and Objective: With over 250,000 metabolic and bariatric surgeries performed in the United States annually, there has been an interest in minimizing preoperative surgical risk and thus optimizing surgical outcomes. One of the recent strategies to accomplish this is by instituting prehabilitation, defined as a preoperative program with the goal of improving functional capability and consequently, postoperative outcomes. Improved outcomes have been associated with prehabilitation in other surgical subspecialties, such as cardiovascular and orthopedics. However, the role of prehabilitation within metabolic and bariatric surgery remains unclear. In this review, we aim to present and summarize the available literature surrounding prehabilitation, as well as discuss its implications and clinical practicality.

Methods: A literature search was conducted using PubMed/MEDLINE and OVID databases, as well as Google Scholar, to identify relevant articles on prehabilitation in bariatric and metabolic surgery. Studies published until June 28, 2022, were considered.

Key Content and Findings: The structure and timeframe of prehabilitation programs, as well as the measurement of targeted outcomes, are highly variable in current literature. Although prehabilitation may benefit select bariatric patients by increasing cardiopulmonary fitness, improving quality of life, or inducing favorable physiological changes, there are conflicting or inadequate data, likely due to the heterogeneity of the programs. High-risk patients are commonly excluded from these studies, although they may benefit the most from prehabilitation.

Conclusions: A formal recommendation has yet to be made regarding which patients should undergo prehabilitation, as well as the optimal and timing of the intervention. Future studies should provide a standardized definition of prehabilitation, extend the follow-up period, and expand the patient population to include high-risk individuals.

Keywords: Prehabilitation; preoperative exercise; bariatric surgery

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Introduction

Obesity is a growing medical problem among the global population. Within the United States, approximately 41.9% of adults are considered to have obesity as of 2021, with 9.2% categorized as morbidly or severely obese (1). Obesity often does not occur independently; the numerous comorbid conditions, such as Type 2 diabetes mellitus, obstructive sleep apnea, and hypertension, can complicate management of this patient population. Metabolic and bariatric surgery remains the most successful long-term treatment for obesity and its comorbidities, and the number of these procedures performed annually has been rising with over 250,000 cases per year in the United States (2-4). However, patients planned to undergo bariatric surgery are not without inherent perioperative risks: they are at increased risk of venous thromboembolism, impaired ventilation secondary to decreased pulmonary compliance, and altered drug metabolism (5-7), all of which are ultimately related to obesity. There has consequently been growing interest in minimizing these risks preoperatively, and the concept of "prehabilitation" has been introduced as means of doing so. While rehabilitation refers to physical conditioning following surgery, prehabilitation encompasses an intervention before a procedure with a goal of improving functional capacity (activity tolerance, mobility, strength, *etc*.) and subsequently, surgical outcomes (8,9). Structured exercise is therefore a crucial component to prehabilitation and was a required intervention for inclusion in this review. Dietary education and psychological counseling may be included with exercise, and altogether they can be considered a multimodal version of prehabilitation (10). Additionally, it is important to highlight the difference between prehabilitation and preoperative weight loss. Although they may utilize the same strategies (exercise, dietary changes, etc.) and can occur concurrently, they differ in their goals. Preoperative weight loss primarily focuses on lowering the kilograms or pounds displayed on a scale, and one can achieve this without improvements in functional capacity. Conversely, it is also possible to increase functional capacity without weight loss.

Prehabilitation is more commonly used in surgical subspecialties that care for frail patients or perform procedures with high morbidity or mortality, such as orthopedic and cardiovascular surgery. In these populations, prehabilitation is frequently associated with improved postoperative outcomes, although there is some variability in results due to different regimens across studies (11-15). In comparison, bariatric surgery patients represent a younger population with an average age of 45 years (16,17), and the procedures have relatively low complication rates with 30-day morbidity and mortality of 6.76% and 0.14%, respectively (18). Because the bariatric population is newer to prehabilitation and starts with an overall lower preoperative risk compared to previously studied groups, current trends and associated outcomes are unclear. In this narrative review, we present the available literature surrounding prehabilitation and discuss its implications and clinical practicality. We present the following article in accordance with the Narrative Review reporting checklist (available at https://ales.amegroups.com/article/view/10.21037/ales-22-51/rc). (19).

Methods

The literature search was conducted using PubMed/MEDLINE and OVID databases, as well as Google Scholar; the search strategy is summarized in *Table 1*. All studies published until June 28, 2022 were considered. Although prehabilitation is a relatively new term, articles from all time periods were searched with the term "preoperative exercise" to capture studies utilizing an intervention that may qualify as prehabilitation today but was not labeled as such because the term did not exist at the time. Pilots, prospective studies, randomized controlled trials, as well as systematic reviews and metaanalyses, were included. Articles that did not involve a structured exercise program in prehabilitation (i.e., only dietary changes or psychological counseling) were excluded, although studies that reported on exercise combined with another intervention were still included. Duplicate articles, editorials, conference abstracts, and publications in a language other than English were also excluded. The references of individual articles were reviewed, and relevant publications were included. An example search per author instructions and table summarizing the included primary articles are available in the supplementary appendix online (Figure S1 and Table S1).

Discussion

Definition of prehabilitation

The initial step in evaluating the effects of an intervention is to establish a consistent and well-accepted definition of the intervention itself. For the purpose of this review,

Table 1 Search strategy

Items	Specification
Date of search	June 28, 2022
Databases and other sources searched	PubMed/Medline, OVID, Google Scholar
Search terms used	("prehabilitation" OR "preoperative exercise") AND ("bariatric surgery" OR "metabolic surgery" OR "gastric bypass" OR "sleeve gastrectomy" OR "Roux-en-Y gastric bypass" OR "one anastomosis gastric bypass" OR "biliopancreatic diversion with duodenal switch" OR "single-anastomosis duodenal-ileal bypass with sleeve gastrectomy")
Time frame	January 1990–June 2022
Inclusion and exclusion criteria	Inclusion: articles describing prehabilitation in bariatric surgery
	Exclusion: no exercise intervention, language other than English
Selection process	Search conducted by the first author (RDM). All authors (RDM, CFM, SS) reviewed the selected articles, and consensus was reached by discussion regarding an article's contribution to the review. Any discrepancies were resolved by discussion in a consensus meeting

prehabilitation was defined as a preoperative intervention intended to improve functional capacity and thus included exercise and physical conditioning. However, this is not always reflected in the current body of literature, which still presents some inconsistencies. As there continues to be growing interest in multimodal and multidisciplinary approaches in healthcare, the term prehabilitation has expanded to interventions such as lifestyle changes, dietary modifications, and psychological counseling. In other words, the definition can be as broad as anything that promotes health and wellbeing of a patient prior to surgery (20). Studies that were encountered but not ultimately included in the review considered passive monitoring of exercise and only dietary counseling to be prehabilitation (21-23), which does not align with our definition. Even among the studies that agreed with our definition and were included for review, there was notable variability across the interventions. For instance, Türk *et al*. combined supervised exercise sessions with dietician visits and motivational psychotherapy for their intervention group (24), and García-Delgado *et al*. added pulmonary rehabilitation with incentive spirometry (25). Lemanu *et al*. further generalized prehabilitation to any process that initiates the recovery process before surgery to better prepare patients for the upcoming stress, including smoking and alcohol cessation (26). A standardized definition of prehabilitation is important to provide clarity across future publications and improve knowledge translation. Until one is established within the surgical community or the bariatric subspecialty, research on the topic will unfortunately remain weak, and it will be difficult to generate evidence-based guidelines.

Comparison to current practice

There is also the question of how prehabilitation fits in with current recommendations and practice in the preoperative care of bariatric patients. The American Society for Metabolic and Bariatric Surgery (ASMBS) does not recommend a requirement of preoperative weight loss due to the lack of an association with improved outcomes or postoperative weight loss (27). However, the ASMBS does support a period of calorie restriction preceding surgery (often resulting in some weight loss) to reduce liver volume and visceral fat (28,29); these changes are intended to improve intraoperative visualization and decrease the risk of conversion to open (30,31). The ASMBS did not provide a formal recommendation in support of preoperative exercise for patients undergoing laparoscopic bariatric surgery due to insufficient data (27). Previous literature involving patients who had undergone major abdominal surgery demonstrated a reduction in complications with prehabilitation (32,33), but these findings could not be fully extrapolated to the bariatric population.

In order to obtain financial clearance in the United States of America (USA), almost all insurance providers have requirements for patients to undergo a supervised medical weight management program, educational sessions, and psychosocial evaluation (34,35). Since approximately 70% of patients undergoing bariatric surgery in the USA have private insurance (36), a majority will be subject to

these conditions. Insurance providers and the Centers for Medicare and Medicaid Services have not yet commented on prehabilitation, and there is likely an overlap between the goals of prehabilitation and their preoperative requirements. Canada, which has a universal publicly funded health care system, requires at least six months of commitment from patients to engage in behavior modification, nutritional therapy, and maintenance of this treatment plan before approval for bariatric surgery (37). The United Kingdom National Health Service (NHS) requires patients demonstrate compliance with a local specialist weight management program for at least six months to qualify for NHS-commissioned bariatric surgery (38). However, none of the included publications studied prehabilitation within the context of fulfilling these criteria, and this may be an area of future investigation.

Similar to the aforementioned mandated preoperative programs, prehabilitation has the potential to be viewed as a barrier to care. Previous studies have identified an association between required preoperative weight management programs and a delay in or decreased likelihood of undergoing surgery (35,39). This highlights the importance of identifying which patients would have the most to gain from prehabilitation; those who would receive little to no benefit may be better suited to proceed to surgery without further delay.

Structure of exercise program

There are currently no evidence-based guidelines regarding the role of exercise in the perioperative care of bariatric surgery patients (40). Consequently, there were multiple variations of prehabilitation regimens across studies: supervised versus unsupervised, aerobic conditioning or strength training, and differences in duration. Additionally, some programs were individualized using baseline strength or maximum heart rate. Most prehabilitation programs had some degree of supervision. Partially supervised programs either began fully supervised and transitioned to unsupervised once patients were adequately trained (41), or required missed in-person sessions be performed at home without supervision (42). Unsupervised programs monitored activity through patient-recorded diary entries and fitness tracker data (25,43).

While all prehabilitation programs involved aerobic exercise, the intensity at which it was performed was highly variable. The least physically demanding intervention was walking at least 30 minutes per day for five days a week. Although this did not lead to significant changes in weight or body composition, there were physiologic improvements detected in insulin sensitivity and inflammatory markers (43,44). On the other end of the spectrum, several programs utilized high intensity interval training (HIIT) for aerobic activity (24,45,46), which is characterized by short, repeated bouts of intense effort as determined by a heart rate and/or oxygen consumption (VO_2) of 60–80% of an individual's maximum. Even though these participants demonstrated significant weight loss following the prehabilitation program, it is important to acknowledge that these patients were physically capable of engaging in strenuous exercise despite their obesity, which presents a significant confounder associated with their baseline condition.

Most studies added resistance or strength training with weights and/or resistance bands. Since baseline strength tends to be highly variable, almost all resistance programs were individualized using a participant's one maximum repetition (41,45-47). The one study that did not personalize strength training provided patients with resistance bands and instructions for specific exercises (25). Stretching was infrequently incorporated, with only four studies including it in their program. Three programs with stretching also utilized both HIIT and strength training, so the stretching could have been a means of ensuring adequate recovery following strenuous activity (45,46,48). The fourth study incorporated stretching in the context of aquatic exercise for balance, mobility, and relaxation (49).

The duration of prehabilitation ranged from one to six months, with most programs planned for three months. Although three months coincides with the wait times associated with the standard preoperative workup and insurance-mandated medical weight management program, improvements have been following shorter sessions. Lucini *et al*. described enhanced hemodynamic load, metabolic reserve, and autonomic regulation following only a month of prehabilitation (50).

Outcomes of interest

A majority of studies evaluated the changes in weight or body mass index (BMI) following prehabilitation; this was driven by previous research suggesting that greater preoperative weight loss may lead to (I) fewer postoperative complications and (II) greater postoperative weight loss (51,52). However, these conclusions have since been challenged and the role of prehabilitation in achieving these outcomes remains unclear. The only study that reported

postoperative clinical outcomes by Gilbertson *et al*. found that prehabilitation (30 minutes of walking, five days a week) was associated with a significantly shorter hospital length of stay of 41.3 hours compared to 56.7 hours observed in the control group, although there was no difference in weight loss (43). No postoperative complications were reported in their study population; thus, no conclusion could be made about those outcomes. Although no other literature reported postoperative complications, multiple studies provided an indirect assessment by evaluating changes in cardiopulmonary health and fitness metrics following prehabilitation. Participants in the Pre-Surgical Exercise Training (PreSET) trial underwent 12 weeks of personalized strength and aerobic training, which resulted in significant improvements in weight, BMI, six-minute walk and half-squat tests preoperatively and at one year postoperatively compared to a control group (47,53). Hardy *et al*. also demonstrated preoperative improvement in the six-minute walk test with a similar prehabilitation program, although they did not find a difference in BMI and their follow-up did not extend to the postoperative period (41). In the Bari-Active trial, patients in the prehabilitation arm were instructed to increase their daily steps with walking and provided with strategies to maximize physical activity. This intervention group demonstrated significantly greater physical activity, as measured by an armband monitor, than the control group in the preoperative period, but this phenomenon was not sustained postoperatively (54,55). A systematic review of perioperative exercise training in bariatric surgery provided further support of this; in the subgroup analysis of preoperative interventions, exercise was associated with greater walking test distance and strength (56).

Overall, literature describing postoperative results is limited. Multiple studies found their prehabilitation cohort had significantly more weight loss than the control group preoperatively, but these patients were not followed into the postoperative period (45,46,50) Among those that reported outcomes after surgery, the data is inconsistent; the PreSET trial demonstrated significantly greater weight loss following surgery in the prehabilitation group when compared to the control, and Gilbertson *et al*. did not find a difference between the cohorts postoperatively (53,57). These conflicting findings could be related to the different follow-up periods; the PreSET trial monitored patients for 12 months while Gilbertson *et al*. did for one month.

Quality of life was another outcome reported in the literature. The Laval questionnaire, which evaluates weight-related quality of life and has been validated in individuals with morbid obesity, was the most frequently used tool. Other surveys included the 36-Item Short Form Health Survey (SF-36) and Asthma Quality of Life Questionnaire (AQLQ). In the PreSET trial, there was no difference in quality of life during the preoperative and postoperative periods when comparing prehabilitation and control groups (47,53). Likewise, Funderburk and Callis reported no difference in SF-36 responses preoperatively (49). In contrast, Hardy *et al*. and Marc-Hernandez *et al*. found significant improvements in preoperative quality of life with prehabilitation when compared to a control using the Laval and SF-36 questionnaires, respectively (41,45). Türk *et al*. evaluated asthma-specific quality of life with the AQLQ and found the prehabilitation group (12 weeks of supervised HIIT, dietary changes, and counseling) to have significantly better results than the control in the preoperative period (24). Interestingly, Gilbertson *et al*. associated prehabilitation with a significant improvement in QoL in the preoperative period but not postoperatively (44,57).

A few studies described physiologic changes (or lack thereof) following prehabilitation, such as alterations in biomarkers and fat oxidation. As mentioned previously, Lucini *et al*. demonstrated four weeks of unsupervised aerobic activity (30 minutes per day) resulted in improved cardiovascular performance as evaluated by echocardiography, serum insulin levels, and resting metabolic rate (50). In the postoperative periods of the PreSET trial and study by Gilbertson *et al*., there was no difference in resting heart rate or blood pressure when comparing prehabilitation and control groups (53,57). When Gilbertson *et al*. evaluated fat-related inflammation via adiponectin and leptin levels and insulin sensitivity using a mixed meal tolerance test, there were significant improvements in both among prehabilitation participants when compared to the control cohort (43,57). Similarly, Picó-Sirvent *et al*. evaluated fat oxidation using a cycle ergometer and found their prehabilitation program (6 months of supervised strength and aerobic training) to be associated with greater maximum, but not overall, fat oxidation when compared to control subjects (48). A meta-analysis of five randomized controlled trials on preoperative exercise in bariatric surgery found that this intervention was associated greater cardiorespiratory fitness or VO_{2max} that was statistically significant, but with modest clinical significance as the quantified improvement was 1/3 of a metabolic equivalent of task (MET) (58).

Limitations

A consistent limitation across prehabilitation research in bariatric surgery is the lack of generalizability and unclear application to clinical practice. The commitment required to participate in an exercise program for several weeks or months is not realistic or desirable for many patients. This is reflected in the low participation rate, with 42–63% of eligible patients declining (25,42,47,54). The most frequently cited reasons were inability to attend regular sessions and lack of interest in the program. Even among patients who agreed to participate, the average attendance was approximately 70% and dropout rates were as high as 67% (42,45,47,55). From the perspective of the surgeon and medical institution, the development and maintenance of a prehabilitation program are time and resource intensive. A physiotherapist or fitness trainer is usually necessary to supervise and guide exercise sessions, and ancillary staff is required to maintain follow-up for patients enrolled in these programs. The cost associated with prehabilitation likely presents a significant barrier to implementation at most institutions. Unfortunately, none of the included studies discussed the specific cost of their programs.

The heterogeneity of the data also limits what can be concluded. There was significant variability in the patient selection, exercise program structures, and reported outcomes such that a recommendation regarding an ideal prehabilitation program could not be made. Regarding patient selection, those who perhaps have the most to gain from prehabilitation were commonly excluded from these studies. Patients who were considered frail, diagnosed with cardiopulmonary disease, or with extremely high BMI (>60) were not considered for inclusion, presumably due to risk of adverse events or functional limitations. However, literature in other surgical areas suggests that these individuals would benefit significantly from such interventions (12,59,60), and more research on bariatric prehabilitation is consequently necessary for high-risk groups.

A limitation of this review itself is the overrepresentation of North American institutions, with nearly three quarters of the included studies originating from the United States or Canada. Although the highest number of bariatric procedures are performed in these two countries, the proportion is less than half of the global count (61). This consequently introduces bias, as practices within other countries are not well captured. European studies comprised the remainder of those included for review, and there was a notable lack of literature from South America, Africa, Asia, and Australia.

Conclusions

In summary, prehabilitation may benefit select bariatric patients by increasing cardiopulmonary fitness, improving quality of life, or inducing favorable physiological changes, as suggested by improvements in fitness metrics (six-minute walk, strength, etc.), survey responses, and laboratory testing (insulin sensitivity, inflammatory markers), respectively (24,41-45,47,54). However, the data so far has been inconsistent secondary to high heterogeneity between protocols and measurement of outcomes. Because the current evidence surrounding prehabilitation lacks consistent findings, we caution against its use as a blanket recommendation to all patients awaiting bariatric surgery. Individuals with above average preoperative risk of complications may be best suited for prehabilitation, although this is based on studies involving non-bariatric patients. A formal recommendation has yet to be made regarding which patients should undergo prehabilitation, as well as the optimal and timing of the intervention. Expansion of studies to include higher risk patient groups is necessary to elucidate potential benefits and add insight to patient selection. Additionally, future research should also work towards establishing a standardized definition of prehabilitation to provide homogeneity across studies and to strengthen the validity of results.

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Supplementary

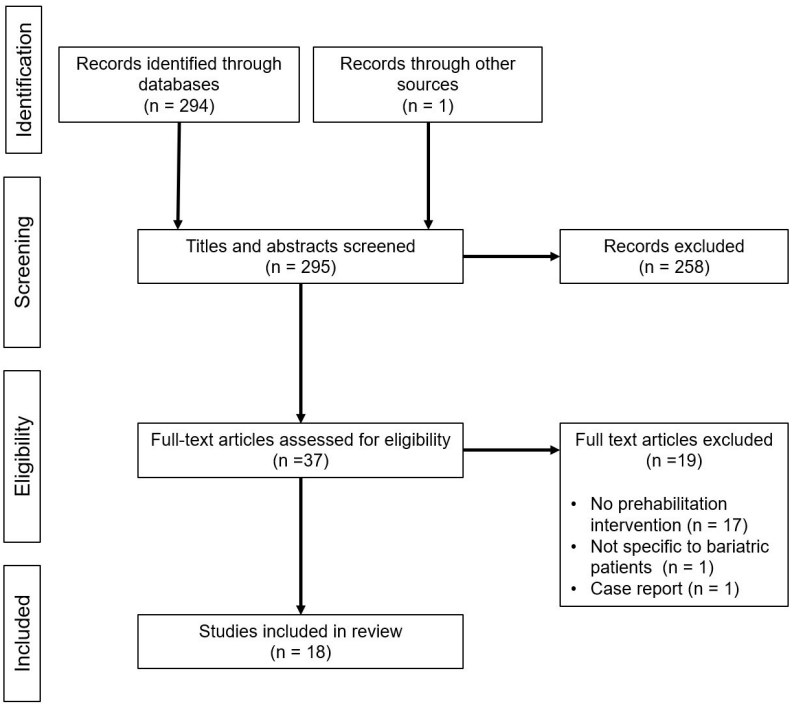

Figure S1 Example literature search per author instructions.

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Table S1 Summary of primary articles

Author	Year	Country	Study Design	Sample Size (n)	Prehabilitation Intervention	Control	Findings Associated with Prehabilitation
Baillot *et al.*	2013	Canada	Pilot of RCT	12	12 weeks of endurance and strength program, twice a week. Partially supervised, personalized, in addition to lifestyle counseling and dietary education.	No control group	Significant decreases in preoperative weight, BMI, and fat mass. Significant improvement in preoperative 6 minute walk, strength, fear of embarrassment and injury on surveys.
Baillot *et al.*	2016	Canada	RCT	30	12 weeks of endurance and strength program, three times a week for 80 minutes. Partially supervised **	Lifestyle counseling, dietary education, physical activity counseling	Significant increase in preoperative 6 minute walk. No difference in BMI, weight, anthropomorphic measures, overall QoL.
Baillot *et al.*	2018	Canada	RCT	25	12 weeks of endurance and strength program, 3 times a week for 80 minutes. Partially supervised **	Lifestyle counseling, dietary education, physical activity counseling	Significant increases in postoperative light and moderate activity, energy expenditure, steps, BMI, and fat free mass. No difference in strength, heart rate, blood pressure or QoL.
Bond *et al.*	2015	USA	RCT	75	6 weekly meetings to discuss increasing physical activity, with goal of increasing walking duration by 10 minutes each session **	Standard preoperative care, encouragement of physical activity	Significant increase in preoperative moderate vigorous physical activity as measured by fitness tracker.
Bond *et al.*	2017	USA	RCT	36	6 weekly meetings to discuss increasing physical activity, with goal of increasing walking duration by 10 minutes each session **	Standard preoperative care, encouragement of physical activity	Significant increase in postoperative number of steps. No difference in postoperative moderate vigorous physical activity.
Funderburk and Callis	2010	USA	RCT	7	12 weeks of aquatic sessions, twice a week for one hour, with goal to increase strength, endurance, and balance **	Standard preoperative care	No statistically significant findings secondary to small sample size
García-Delgado *et al.*	2021	Spain	Pilot of RCT	15	8 weeks of endurance, strength, and respiratory training (incentive spirometry). Not supervised, not personalized, reported by fitness tracker and diary **	Structured educational and behavioral program with dietician, psychologist, and endocrinologist	No statistically significant findings secondary to small sample size
Gilbertson *et al.*	Aug 2020	USA	Prospective cohort	14	4 weeks of walking, 5 times a week for 30 minutes. Not supervised, not personalized, reported by fitness tracker and diary **	Dietary and lifestyle education, psychological clearance	Significant increase in preoperative insulin sensitivity and QoL. Significant decrease in preoperative inflammatory markers and length of stay. No difference in preoperative weight, body fat, blood glucose or triglyceride levels.

Table S1 (*continued*)

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Table S1 (*continued*)

Author	Year	Country	Study Design	Sample Size (n)	Prehabilitation Intervention	Control	Findings Associated with Prehabilitation
Gilbertson *et al.*	Oct 2020	USA	Prospective cohort	14	4 weeks of walking, 5 times a week for 30 minutes. Not supervised, not personalized, reported by fitness tracker and diary **	Dietary and lifestyle education, psychological clearance	Significant increase in preoperative metabolic flexibility. Significant decrease in preoperative adiponectin, operating time, and length of stay.
Gilbertson *et al.*	2021	USA	Prospective cohort	14	4 weeks of walking, 5 times a week for 30 minutes. Not supervised, not personalized, reported by fitness tracker and diary **	Dietary and lifestyle education, psychological clearance	Significant increase in postoperative adiponectin. Significant decrease in postoperative moderate vigorous physical activity. No difference in postoperative body weight, waist circumference, insulin or glucose levels, or QoL.
Hardy *et al.*	2022	Canada	RCT	54	12 weeks of endurance and strength training. Partially supervised and personalized **	Dietary education, physical activity counseling	Significant increase in 6-minute walk and QoL
Lucini *et al.*	2021	Italy	Pilot of prospective cohort*	39	4 weeks of moderate intensity exercise for 30 minutes per day, not supervised, in addition to dietary and psychological counseling.	No control group	Significant decrease in preoperative BMI
Marc-Hernandez *et al.*	2019	Spain	Prospective cohort	23	12 weeks of endurance (HIIT) and strength training, 2-4 times a week, supervised, not personalized **	Dietary education, psychological counseling, encouragement of physical activity	Significant decrease in preoperative weight, fat composition, A1C, and blood pressure. Significant improvement in QoL.
Picó-Sirvent *et al.*	2019	Spain	Pilot of prospective cohort	6	24 weeks of endurance (HIIT), strength, and flexibility training, 2-4 times a week. Supervised, not personalized**	Standard preoperative care	Significantly greater decrease in BMI and excess body weight. No difference in strength.
Picó-Sirvent *et al.*	2022	Spain	Prospective cohort	20	12 weeks of endurance, strength, and flexibility training, 2-4 times a week for 60-70 minutes. Supervised and personalized**	Standard preoperative care	Significant increase in maximum fat oxidation.
Türk *et al.*	2017	Netherlands	Pilot of prospective case-control	4	12 weeks of endurance (HIIT) 3 times a week for 40-60 minutes, supervised and not personalized, in addition to dietary and psychological counseling	Retrospectively obtained matched controls, received dietary and psychological counseling	Significant increase in asthma-related QoL.

*Published as Letter to the Editor. **Prehabilitation intervention was in addition to resources provided to control group. BMI, body mass index; HIIT, high intensity interval training; QoL, quality of life; RCT, randomized controlled trial; USA, United States of America.