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Current Evidence for Physical Activity in the Bariatric Surgery Patient for Weight Loss Success

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Abstract

Leading a physically active lifestyle is critical for optimal health. Observation and intervention studies show that behavioral weight loss in overweight and class 1 obesity (body mass index=30-34.9 kg/m^2) interventions are more successful in the long-term by adhering to a physical activity regimen, including at least 150 minutes per week of moderate intensity exercise. Although substantial research has been conducted in behavioral based weight loss programs, there are very limited studies that have investigated the effect that physical activity has on weight and body composition outcomes in bariatric surgery patients. In that bariatric weight loss surgery is accepted as the most effective short and long-term weight loss intervention for morbid obesity, research in this area needs to be a priority. This review summarizes the current evidence in this realm by examining both pre- and post-surgical studies that have been conducted in this field. Observational studies in individuals eligible for bariatric weight loss surgery indicate the majority of patients have zero minutes of vigorous activity and less than one-half of the recommended moderate activity minutes. In the pre-surgical patient, there have just been a few feasibility studies to investigate the incorporation of physical activity into the behavioral intervention to support weight loss and lifestyle change. These studies were generally confined to a walking program for the surgery patients. Importantly, these did not examine post-operative outcomes. Although weight loss following bariatric surgery is superior to behavioral interventions in severely obese individuals, there is still significant variability in the amount of weight loss achieved. Physical activity is one possible factor that has been examined that may contribute to the variability. Post-surgical observation studies consistently show a positive association between physical activity and improved weight loss, with physical activity and sedentary behaviors being the highest predictors for post-surgery weight loss. In spite of this evidence there are currently no large-scale, long-term randomized trials that have investigated a structured, well-controlled, physical activity intervention in post-surgical patients. The intervention studies to date have been small in number, nonrandomized in design, and were for a short duration. Future directions in this area are many, with questions on the type of exercise prescription that is going to be the most successful for long-term weight loss success and health improvements being on the forefront.

Keywords: Bariatric surgery; Weight loss; Physical activity

Introduction

A corner-stone for optimal health is the incorporation of physical activity into a healthy lifestyle. Specifically, for the management of healthy body weight, physical activity interventions are strongly encouraged by health care providers. Whereas the vast majority of the research for physical activity prescription in weight loss and weight loss maintenance centers around overweight, and class I and II obesity, there is very limited evidence for the use of physical activity in severe obesity (BMI >40 kg/m^2). Thus, physical activity recommendations for this category of obesity are based on research in the lower levels of obesity. Arguably, these recommendations are likely not to provide similar weight loss benefits across these obesity classes and surgical vs. non-surgical weight loss interventions, based on degree of obesity, health behavior adherence, and comorbidities, among other factors, obesity [1-3]. Thus, bariatric surgery patients need to be studied separately and have their own set of recommendations. Furthermore, guidelines specific for incorporating physical activity behaviors in patients prior to and after bariatric surgery is sparse; only a small number randomized trials have been performed, and these are generally limited by small sample size, length of intervention, and inability to assess adherence to the intervention.

Bariatric surgery is commonly accepted as the most effective short and long-term weight loss intervention for morbid obesity, leading to greater and more robust outcomes than non-surgical interventions [4]. It is well-recognized that regular engagement in exercise leads to superior long-term success in behavioral weight loss and maintenance [5-12]. The American Society for Metabolic and Bariatric Surgery recommends 20 minutes of exercise per day, 3-4 days a week before surgery to improve cardiorespiratory fitness and reduce risk of surgical complications [13]. They also recommend a progressive walking program at postoperative day 1 and to increase physical activity (aerobic and strength training) to a minimum of 30 minutes per day as tolerated [13,14]. It is critical to understand that this recommendation is not based on improving weight loss or physical activity behaviors post-operatively. The physical activity recommendations for post-operative patients include exercising for at least 30 minutes/day [15]. Interestingly, the evidence-based physical activity recommendations for healthy and overweight/obese individuals from other organizations (American College of Sports Medicine, Institute of Medicine, for example) call for much greater levels of activity, reaching more than

250 minutes/week of moderate-intensity physical activity from the American College of Sports Medicine [16], and 60 minutes/day of moderate intensity physical activity from the Institute of Medicine [17]. American College of Sports Medicine guidelines for the duration of exercise training for preventing weight regain following significant weight loss has been set at 60-90 minutes/day or 2000 kcals/week of leisure time physical activity [16,18]. However, in practice, these guidelines are rarely followed. In a review of accredited weight loss surgery centers throughout the United States, Peacock and Zizzi assessed behavioral and psychological services available and utilized for surgical patients both pre- and post-surgery [19]. In the 123 centers analyzed, both psychological and behavioral services were likely to be offered and utilized before rather than after surgery. However, there was significant heterogeneity in the centers' staff to offer services, with more centers utilizing clinic staff for dietary behaviors than addressing physical activity needs. In reality, only a few centers employed staffs who are exercise specialists. Furthermore only 2 of the 123 centers required consultation with an exercise specialist post-surgery. Another 14 of the centers provided the option of meeting with an exercise specialist, generally at an additional cost. Furthermore, they found a strong bias for nutrition services compared to exercise services in the patient instruction manuals. These findings illustrate the grave need for improved support to address physical activity behavior changes in surgical patients, especially with observational research demonstrating that exercise is the best predictor of long-term weight loss maintenance [20,21]. Importantly, engaging in regular physical activity is the most likely area of noncompliance following bariatric surgery [22].

In further work in this area, Peacock et al. studied barriers to exercise in post-surgical patients [23]. They found that poor motivation was the most frequently reported barrier to exercise, which may be from negative thoughts that are carried over from poor physical function capacity in the pre-surgical state. Additionally, barriers include lack of time (poor time management), lack of consistency or not getting into the habit of exercising, chronic illnesses/injuries and pain (musculoskeletal disorders), and low energy due to surgery or restricted diet.

For targeting obesity treatment universally, engaging solely in regular physical activity independent of dietary restriction results in small amounts of weight loss (~1-3% of initial body weight). Incorporating physical activity with dietary restriction provides additional weight loss above that seen with dietary restriction alone. Importantly, besides weight loss, physical activity provides additional mental and physical health benefits. Moreover, behavioral change is essential for long-term success and should not be diminished. This includes lifestyle modifications to both dietary habits and physical activity. However, this type of information in bariatric surgery patients is not known as there are currently no evidence-based preoperative or postoperative physical activity guidelines. This review will examine the present support of physical activity for weight loss and body composition changes in bariatric surgery patients. Evidence from both observational and randomized clinical trials are presented and separated based on pre-surgical and post-surgical findings.

Physical Activity in Pre- and Post-Operative Bariatric Surgery Patients

A number of recent studies have described physical activity levels with the consistent finding that sedentary behaviors are predominant and physical activity levels are below recommended levels in bariatric surgery patients [24-31]. Use of accelerometers and other devices for objective measures of physical activity demonstrates most pre-operative patients participate in inadequate levels of physical activity [31,32]. Compared to age and gender matched normal weight controls, bariatric surgery patients had about 50% of the recommended levels of moderate-to-vigorous physical activity minutes and vigorous physical activity minutes. Furthermore, two-thirds of the surgical patients had zero minutes of vigorous physical activity vs. only 13% for controls [32]. In this study, physical activity was assessed using an accelerometer. However, physical activity levels generally are slightly increased and sedentary behaviors are modestly decreased following bariatric surgery [31]. However, in a study that compared severely obese individuals scheduled for either lifestyle obesity treatment or bariatric surgery (matched for BMI, age, and gender), there were no differences between the groups in physical activity patterns as measured by a physical activity monitor [33]. From participants in the multi-site Longitudinal Assessment of Bariatric Surgery (LABS)-2 study who had physical activity level assessed using an accelerometer prior to surgery, almost 50% had enough daily steps to be considered somewhat active (≥ 7,500 steps), but only 20% of them had at least 10,000 steps per day [34]. Furthermore, as collected from physical activity diaries, these steps were accumulated primarily from activities of daily living and not a structured exercise training program. Substantiating the aversive effects of BMI on activity engagement, there was a negative association between BMI and daily step counts, as they report that there were almost 150 fewer steps for every 1 kg/m^2 increase in BMI. In another observational study with bariatric surgery candidates, median step counts were nearly 8,000 steps/day, as assessed by an activity monitor [35]. However, comparable to King and colleagues [34], about 45% of the study participants had less than 7500 steps/day and only 22% had 10,000 steps or more.

After a mean follow-up of 9 years post-surgery, bariatric surgery patients spent nearly 10 hours in sedentary positions [24]. Researchers found that 6-18 month post-surgery patients spent 72% of their time in sedentary behaviors with about one-half of this time in sessions greater than 30 minutes [30]. This was assessed by wearing objective activity monitors for 7 days. In contrast, physical activity was accumulated in bouts lasting less than 10 minutes. In two large observational trials (Swedish Obesity Subjects (SOS) Study and the Longitudinal Assessment of Bariatric Surery-2 (LABS-2)), physical activity was shown to increase from pre- to post-surgery [27,28]. In LABS-2, step counts, active minutes, and high-cadence activity all increased from pre to post-surgery 27. In a separate analysis of a subset of LABS-2, King et al. also presented results showing a 25 minute per day decrease in time spent in sedentary behaviors and moderate-to-vigorous activity time increased from 77 to 106 minutes/week during the first year post-surgery as measured objectively using a physical activity monitor [31]. However, even with the increase in activity, this is less than the 150-250 minutes/week seen with various guidelines. No further changes were observed between years 1 and 3 in these patients. In another study that compared physical activity behaviors during the weight loss maintenance phase between post-surgical bariatric surgery patients and individuals using non-surgical strategies for weight loss, total activity, medium intensity activity, and heavy intensity activity (kcals/week) were all greater in the non-surgical study participants [36]. The non-surgical patients were recruited from the Weight Control Registry and data from their first year in the registry were used for this analysis. Measurements were obtained during the weight loss maintenance period with individuals followed for an additional 1-year after study entry. This study used the Paffenbarger Activity Questionnaire, which asks about total, medium intensity and heavy intensity physical activity

related energy expenditure over the past 7 days. Values were similar within each group between baseline and 1-year periods. However, there was a marked difference in reported total activity kcals expended per week at the end of the 1-year monitoring with ~3000 kcals for non-surgical and ~1700 kcals for the surgical group. Similarly, weekly medium-intensity and high-intensity exercise expenditure at 1-year were ~730 kcals for non-surgical and ~430 kcals for surgical, and ~1130 kcals for non-surgical and ~400 kcals for surgical, respectively. Interestingly, many of these early studies, like this one, relied on self-report measures of physical activity, which are prone to over-reporting [37]. Illustrating this point, in a direct comparison between self-report and objective measures of physical activity from pre-surgery to 6-months post-surgery, study results showed that physical activity increased in patients, but to a much smaller level with objective vs. self-report behaviors [25].

Pre-Surgical

Theoretically, the pre-operative time may provide an opportunity for patients to become motivated to alter lifestyle behaviors to have a successful surgery and post-surgical outcomes. Both observation and intervention studies have been conducted in bariatric surgery patients prior to the operation to test the feasibility of such an intervention, as well to test its effectiveness to increase physical activity.

Observation studies

The measurement of physical activity in bariatric surgery patients is a critical initial step to try and understand if physical activity levels at this time might contribute to the variability or predict weight outcomes post-surgery. Interestingly, an early study in this area by Bond and colleagues showed that physical activity and physical activity readiness in gastric bypass patients increased during pre-surgery [38]. Both physical activity readiness questionnaire and the International Physical Activity Questionnaire were administered at an initial pre-surgical visit and then again at 1-2 weeks prior to surgery. With an average of 3-months separating the visits, patients reported increasing their moderate and vigorous activities between visits. This is further exemplified in the physical activity readiness questionnaire that showed more individuals were in the action and preparation stage and very few in the contemplation and precontemplation stage at visit 2 vs. visit 1. Although a formal activity intervention was not initiated, these data suggest that a pre-surgical intervention that targets physical activity has potential to increase engagement in physical activity. Additionally, Wiklund et al. examined the experience bariatric surgery patients have with physical activity, with the understanding that this information could individualize the approach and information on physical activity to this severe obese population [39]. In this qualitative analysis of semi-structured interviews with bariatric surgery candidates, several consistent factors were described. These include a patient expressing a positive experience after being physically active; excess weight hindered activity, but weight loss was thought to make physical activity easier; wearing exercise clothing in public brought about an uncomfortable feeling; and most patients had multiple perceived obstacles that influenced their ability to exercise.

An outcome of improved physical activity is an increase in an individual's physical fitness. For a number of types of surgeries, higher post-surgical risks are evident in less physically fit individuals [40]. This is also apparent in gastric bypass pre-surgery patients [41]. Bariatric surgery patients with a low pre-operative anaerobic threshold as measured by a graded exercise test had a longer length of stay in the hospital and a low anaerobic threshold was also associated with greater postoperative morbidity. Thus, improvement of physical fitness through a pre-surgical physical activity intervention may help with post-operative outcomes.

With the evolving evidence demonstrating the independent health risks of sedentary behaviors for weight gain and cardiovascular disease [42-44], several studies have investigated these behaviors in bariatric surgery patients. Not surprisingly, these individuals spend the majority of their day in sedentary behaviors (a waking behavior that expends <1.5 METs), mostly watching television or performing paper or computer work [45]. Together, these two sedentary activities accounted for almost 5 of the nearly 10 hours per day participants reported in sedentary behaviors. The time per day spent being sedentary (9.5-11 hours) has been consistent across several other studies using both objective and subjective instruments [45-47]. This suggests that interventions need to be tailored that not only increase moderate-to-vigorous physical activity, but also lessen screen time with television, computers, and hand-held devices.

Intervention studies

Pre-surgical behavioral intervention to support weight loss and lifestyle change is the standard of care as recommended by the American Society for Metabolic and Bariatric Surgery and is provided by the majority of large comprehensive bariatric surgery programs [19]. Brandenburg et al. demonstrated that a 6-week pre-operative program focused on changing lifestyle behaviors, for which exercise was a single component, to improve post-surgical outcomes was well received by patients; furthermore, at 1-year post-surgery, they reported that the program assisted them in making post-surgical lifestyle changes [48]. Interestingly though, there were no correlations between patient satisfaction and perceived usefulness of the program and post-surgical weight loss. In a recent review, King et al. showed that engaging in physical activity prior to surgery may help to optimize weight loss and other surgical outcomes [49]. However, increasing physical activity is not a standard behavioral component of pre-operative care.

The Bari-Active study was a randomized controlled trial that tested the efficacy for a pre-surgical intervention to increase physical activity in bariatric surgical patients [50,51]. In this study, a 6-week behavioral physical activity intervention was compared to a standard care control group for pre- to post-intervention changes in the number of minutes of moderate-to-vigorous physical activity, quality of life, and physical function as well as number of daily steps. The intervention consisted of weekly individual behavioral sessions with performance goals of increasing moderate intensity walking exercise by 30 minutes/day and to increase step counts by 5,000/day. Compared to baseline testing, there was an increase of 21 minutes per day in moderate-to-vigorous physical activity after 6-weeks for the physical activity intervention group, while the control group showed no change in moderate-to-vigorous physical activity minutes. Similarly, step counts increased by over 2,000 in the physical activity intervention group compared to 200 in the controls. Even with this increase in activity, which was below the performance goals, only 30% and 14.3% of participants in the physical activity intervention and control groups, respectively, met the national guideline of 150 weekly minutes of bout-related moderate-to-vigorous physical activity [52] at the end of the study. Additionally, physical and mental health improved more for the physical activity intervention group than the control group. The trial demonstrated that enrolled study participants were able to complete the intervention as

demonstrated by a high retention rate; however, the majority of patients screened refused to participate in the study. The practicality of such an intervention in surgical patients is thus questioned. Importantly, the study did not examine the effect of the intervention on post-operative outcomes.

In a feasibility study, a combination of a strength and endurance training program lasting 12 weeks was tested in bariatric surgery patients to test adherence and satisfaction to the exercise program [53]. This was a combination of facility-based and home-based training with a prescription of at least 3 days a week of exercise. Participants attended nearly 60% of the supervised exercise sessions. Importantly, there was a high satisfaction rate for the program, as well as improvements in health related quality of life, physical fitness, and weight loss from baseline measures. Although this was not a randomized control trial and no post-surgery outcomes were assessed, it did demonstrate adherence and effectiveness of a pre-surgical exercise program on psychosocial measures.

Parikh et al. tested in a randomized control trial the effect of a 6-month medically supervised weight management program in pre-surgical bariatric patients on weight loss and lifestyle behaviors immediately after surgery, and at 6-months post-surgery [54]. Participants were randomized to either a control group that received no further intervention, or a group that attended monthly multi-disciplinary behavioral meetings (one group had individual meetings and one group had group meetings). They found no differences between those in the monthly meetings and the control group with regards to weight loss at 6-months post-surgery. They did show an increase in physical activity from baseline to immediately post-surgery for the medically supervised group, but this was not apparent at the 6-months post-surgery visit.

In another study, implementation of a pre-surgery lifestyle behavior program that included exercise as a component resulted in only 45% of the respondents reporting exercising at least 3 days a week and only 20% reported exercising at least 5 days a week at 1-year post-surgery [48]. Of those reporting that they engaged in exercise, only one-third exercised for at least 90 minutes each week, which is below the 150 minute/week recommendation. No further delineation of exercise duration and intensity were mentioned in the study. Similarly, a pre-operative counseling intervention did not affect lifestyle behavioral outcomes measured 1-year post bariatric surgery [55]. At post-testing, only 37% of patients reported participating in at least 30 minutes of daily physical activity, and there were no differences in weight loss or physical exercise between individuals that were in the counseling group compared to the control group. More telling thought was that 31% of subjects in the study who were offered counseling sessions chose not to participate, indicating the difficulty in providing an intervention to this cohort.

The relatively few studies that implemented a pre-surgical physical activity intervention, varied tremendously in design with regards to exercise prescription and behavioral intervention strategies [48,50,54-56]. Furthermore, the relative success with regards to adherence, changes in outcomes as compared to control groups, and long-term post-surgical implications is quite inconsistent. Thus, the lack of data in this area makes it difficult to make conclusions or establish guidelines. This indicates that well-designed, controlled trials are lacking in this area, and needs to be a priority in order to understand and develop guidelines for physical activity in this understudied cohort.

Post-Surgical

Although weight loss following bariatric surgery is superior to behavioral interventions in severely obese individuals, there is still significant variability in the amount of weight loss achieved. In attempts to identify factors that may contribute to the variability, physical activity after surgery has been examined from both observational and intervention studies, while currently there are no large scale, long duration randomized controlled intervention studies, several smaller, shorter duration studies have been conducted.

Observation studies

In this section observational evidence will be described demonstrating the relationship between physical activity and weight loss in post-surgical bariatric patients. In the last 25 years, a number of studies have consistently shown that engagement in physical activity in post-operative patients is a factor associated with improved weight loss and/or weight loss maintenance [57-67]. This is also apparent across different types of bariatric surgeries. In contrast, only a limited number of studies have demonstrated a lack of or a negative relationship between specific physical activity variables and post-surgical weight loss [68-70]. Based on the American College of Sports Medicine's recommendation to participate in at least 150 minute of moderate or higher intensity physical activity per week, Evans et al. compared weight loss in post-bariatric gastric bypass surgery patients that were divided into two groups- those that reported at least 150 minutes of moderate intensity per week and those that reported less than 150 minutes [60]. At both 6- and 12-months post-surgery, weight loss was significantly greater in the individuals reporting at least 150 minutes/week of moderate activity. The difference between groups was about 6% greater excess weight loss at each time point. This association of physical activity and weight loss was apparent even up to 16 years post-surgery [59] after controlling for age, gender, surgery type, presurgery BMI, weight loss, and time since surgery.

In these observational studies, measures of physical activity and sedentary behaviors are not only statistically associated, but these assessments are frequently among the highest, if not the highest, predictors for post-surgery weight loss success. Among 20 variables selected from patient demographics, medical comorbidities, weight history, postoperative outcomes, and health behaviors, low physical activity and high initial BMI were the strongest predictor of poor weight loss after gastric bypass surgery [58]. As the authors state, this limited physical activity participation by patients is a prospect for substantial pre-and post-surgical intervention to optimize weight loss post-surgery. Findings from others also demonstrate that becoming active post-surgery provides as much if not more weight loss success than maintaining activity behaviors from pre- to post-surgery [57]. This was demonstrated in a study where nearly 200 gastric bypass surgery patients were classified into one of three groups based on their activity level pre- and post-surgery, respectively, as either active (≥ 200 minutes/week) or inactive (<200 minutes/week): Active/Active; Inactive/Active; Inactive/Inactive. Those patients that became active post-operatively realized greater weight loss than patients that remained active or remained inactive.

Intervention studies

A somewhat limited number of published intervention studies in post-surgical bariatric patients have investigated physical activity in this cohort. However, very few have investigated the physical activity

intervention as a randomized controlled trial or have studied weight loss as a post-surgical outcome. For example, skeletal muscle lipid oxidation, but not body weight was assessed in post-bariatric surgery patients following a 10-day exercise training program [71]. A 12-week exercise training program examined heart rate kinetics and physical function, but not body weight or body composition, in women following gastric bypass surgery [72,73]. Additionally, neither of these studies compared a control/usual care group with an exercise training group. However, findings from these studies can be forth telling by describing the feasibility of implementing the exercise training program in this cohort, as well as retention rates and attendance to sessions.

In a nonrandomized, retrospective review of medical records, participation in an individual personal trainer exercise program in post-surgical patients lead to greater weight loss at 12-months, but body weight at 36-months did not differ between those that attended at least one personal trainer session compared to those that did not attend any of these sessions [74]. This provides preliminary evidence that participation in a post-surgical exercise program can be beneficial for short-term weight loss as shown by an additional 6 kg loss in these patients at 12-months.

In a recent multi-site prospective randomized clinical trial, a total of 128 men and women who had gastric bypass surgery were randomized into a 6-month exercise training program or a health education control group [75], with an average of nearly 80 days between surgery and intervention initiation date. The exercise training was described as semi-supervised and moderate intensity with a goal of 120 minutes/week of moderate-to-vigorous activity. There was less than a 10% drop out of randomized participants from both intervention groups in the 6-month study. The mean amount of weekly exercise time for the exercise group was 147 minutes measured over the second half of the study; moreover, two-thirds of the participants in this group performed at least 120 minutes of exercise per week with a mean in this subset of 185 minutes. Not including those that dropped out, there were 16 participants in the exercise training group who did not achieve the intervention goal, and they averaged fewer than 60 minutes of activity a week during the final 3-months of the study. In this nonadherence group, five had health issues not related to the intervention, two lived an extensive distance from the exercise facility, and 9 had no obvious explanation for nonadherence. For body weight and body composition, there were expected changes between baseline and post intervention, but there were no intervention group effects.

In a small (n=8) nonrandomized study of women, participation in a short-term (8-week) lifestyle intervention that included behavior modifications for physical activity and nutrition resulted in a greater percent of weight loss than historical controls from 3-12 months post-surgery (12.2% vs. 5.1%) [76]. Moreover, physical function, participation in strenuous intensity exercise, dietary intake, and quality of life all improved with participation in the intervention program. This intervention was initiated when patients were 3-6 months post-surgery. The exercise program was a once-a-week facility based program for 60 minutes that was led by either an exercise specialist or physical therapist. There was a combination of resistance training and cardiovascular exercise at these sessions. Additionally, patients were instructed to exercise at home for at least 30 minutes a day for 5 days a week with resistance bands and walking exercise, with activity diaries kept by participants to verify adherence to the intervention.

Both strength and endurance training was included in a pilot, nonrandomized trial of post gastric bypass surgery patients [77]. Participants were able to choose whether they wanted in the exercise trained or the notrained group. A total of 19 individuals were tested at baseline (10 in the trained and 9 in the untrained groups); there were 2 dropouts from each so that the final sample size with 8 in the trained and 7 in the untrained group. The trained group met 3 times a week for 12 weeks, 75 minutes each session. There were 25 minutes of strength training and 30 minutes of endurance training each session. The final goal for the resistance training was 3 sets of 10 repetitions at 75% of the 1 repetition maximum for both elbow and knee flexion and extension. The endurance training was a mix of cycling, walking and stepping at 60% of heart rate reserve. At the end of the intervention, both groups lost similar amounts of weight and had similar changes in body composition with a loss of both fat mass and fat-free mass. Benefits from the exercise training program were apparent compared to the untrained patients with regards to muscle strength, but not for peak exercise capacity or physical function.

In a randomized trial of Hispanic Americans (n=144), a 12-week comprehensive nutrition education program was initiated at 6-months post gastric bypass surgery with weight loss and physical activity levels being the primary outcomes of this study [78]. Participants met in a group setting every-other-week for 6 sessions, 90 minutes per session. Only one of the sessions dealt specifically with physical activity as a way to assist with weight loss and weight loss maintenance. Compared to the noncomprehensive approach intervention, those in the comprehensive program lost more excess weight (80% vs. 64%) at 12-months, and they participated in more minutes of physical activity per week. At the initial assessment that occurred 6-months post-surgery, 74% of participants reported engaging in some type of physical activity. After the 6-month intervention, 82% of the comprehensive group and 67% of the noncomprehensive reported regularly engaging in exercise, with walking the most frequent activity. The mean time of exercise increased by 14 minutes/week in the active intervention group, whereas the comparison group decreased their level of activity by 4 minutes/week. This study suggests that a very mild promotion of a comprehensive approach for weight loss in post-surgical patients can have slight positive effects on physical activity behaviors and weight loss, even after the end of the group intervention in this ethnic specific cohort.

Shah et al. tested the feasibility and effect of a 12-week high-volume exercise program in a randomized controlled trial design in post bariatric surgery patients [79]. The exercise goal was to expend at least 2,000 kcals/week by weeks 4-12 in moderate-intensity exercise (60-70% of maximal oxygen consumption). Participants were randomized to the progressive exercise training program (n=21) or a control group (n=12). The exercise participation goal was to exercise at least 5 days a week, with at least 1 or 2 sessions occurring in the fitness facility. Approximately one-third of the exercise group performed all their exercise sessions at the facility. The energy expenditure was estimated from the physical activity diary kept by participants. The attrition rate was 33% (4 out of 12 dropped out) for the control group and 24% (5 out of 21 dropped out) in the exercise group. About 50% of the participants in the exercise group achieved the 2,000 kcal/week energy expenditure goal at 12-weeks, with more than 80% reaching an expenditure of 1,500 kcals/week from moderate-intensity exercise. Consistent with these results, step counts increased in the exercise group from 5,500 at baseline to almost 10,000 at 12-weeks, with minimal change in the control group. Also maximal oxygen consumption improved from 17.4 ml/kg/min to 19.2 ml/kg/min for the exercise group, with no change seen in the control group. As expected, both groups showed significant changes in body weight and body

composition, but noteworthy, there were no differences between groups. This feasibility study showed some success in having about 50% of patients achieve the exercise goal, and the approximately 10% improvement in cardiovascular fitness is related to lower mortality [80].

There is rationale for inclusion of a resistance training exercise program in post bariatric surgery patients, as it is hypothesized to attenuate the loss of fat-free mass during the calorie-restricted weight loss period [81,82], as well as to increase strength for improved physical function [77,83-85]. In a nonrandomized pilot study testing a 12-week resistance training program in post bariatric surgery patients (n=19), body composition, body weight, and physical fitness (strength, cardiorespiratory fitness) were assessed in patients who started the exercise program within the first year after bariatric surgery [86]. The 60-minute/day small group (n=5) training program occurred twice a week for the first 6-weeks and then three times a week for the last 6-weeks. The training included was heavily based on resistance training (45 minutes) and minimal cardiovascular training (10 minutes). All major muscle groups were targeted with the 8-10 stations. The workout goal was 3 sets of 8-12 repetitions at each station with only 60 seconds rest between sets and stations. This intervention achieved a high rate of adherence as patients participated in 84% of the training sessions, with no adverse events occurring. There were no differences between those participating in the training group and the usual care group with regards to body weight or body composition assessments. However, the training did result in improved function and fitness. This study was limited in the timing of the initiation of the intervention was diverse after surgery. The significant heterogeneity in the rate of weight loss during this period would likely influence the impact of different modalities of exercise training on body composition.

Research Limitations

From this review, it is evident that most of the support for promoting exercise in morbidly obese individuals who are undergoing bariatric weight loss surgery is from observational studies. Currently, there are no large-scale randomized trials to specifically address this issue. This is troublesome in that this lack of high level evidence makes it difficult to develop specific physical activity guidelines in this cohort. Therefore, no specific and clearly defined recommendations can be made. In the following section, a number of future objectives are discussed to help guide research in the targeted direction. It is promising that current findings from a few small pilot studies that examined efficacy support improved outcomes following surgery when an exercise training program was instituted. Confounding the results from these studies are the various designs and types of programs utilized, such as time of implementation of the program since the surgery, the length of the program, and the strength of the behavioral modification component to enhance adherence. To determine the compliance to the intervention, the level of physical activity needs to be assessed. As reviewed above, measurement of physical activity using objective means, such as with activity monitors, provides a better calculation of physical activity behaviors as compared to subjective assessment. When implementing a physical activity program, its effectiveness will be dependent on how well study participants adhere to it, which needs to be assessed via an objective or subjective instrument. Determining physical fitness changes along with physical activity behaviors may help provide insight into the mechanism for the benefits of an exercise program.

In a bariatric surgery clinic, ideally, the exercise clinician sets goals with patients to gradually increase activity. However, most bariatric surgery clinics are not staffed with Exercise Physiologists to provide safe and effective goals for patients. Those that are staffed with exercise professionals have limited time (i.e., 1 or 2 visits) to assist with setting and progressing an exercise program. What could be most beneficial to an obese patient is mastery through incremental exposure to varying types and increasing intensities of activity. A complete exercise program involves cardiovascular, resistance and flexibility training combined with goals and encouragement around also increasing incidental lifestyle activity. Patients can have a broad range of abilities, barriers and goals and, therefore, more exposure to exercise professionals can assist patients in overcoming barriers and adopting long-term exercise as part of their obesity treatment. Adopting an active lifestyle, which includes regular exercise and physical activity, requires focused attention on an individual's overall experience and health status.

Conclusion

Based on this review, the low level of physical activity and high level of sedentary behaviors present in surgical patients should serve as a guide for healthcare professionals to target and reverse these behaviors. On the upside, Wouters et al. found favorable changes in exercise acceptance and contemplation about exercise after bariatric surgery, possibly making it conducive for a physical activity intervention [29]. These included a decrease in embarrassment and fear-of-injury, and a stronger belief in the benefits of exercise and an increase in confidence in exercising.

Future Questions

Many questions surround the ideal exercise prescription for an individual who is morbidly obese and undergoing bariatric surgery for weight loss. This lack of data leaves the exercise practitioner to base exercise guidelines on those developed for other populations. Guidelines for the general public may not be enough to stimulate the appropriate response in individuals who are losing or who have lost a large amount of weight. The small amount of existing research does not answer questions about appropriate timing, modalities, intensity or dose. Exercise recommendations can also not exclude the many barriers this cohort faces (including physical limitations, lack of appropriate equipment in many standard gyms, embarrassment, anxiety and a state of extreme deconditioning). Finding an appropriate exercise prescription in this population must also take into consideration the motivation of the patient and the ideal time to intervene based on multiple factors, such as patient readiness, past patient experience, preventing loss of lean mass, patient energy level, and health complications, among other factors. Finally, it is important to note that, based on the small body of research noted; most patients lose weight regardless of activity level. Therefore, exercise may best be promoted as a weight maintenance strategy rather than to elicit additional or accelerated weight loss. Furthermore, it must not be forgotten that exercise may be more important in addressing body composition changes and obesity-related comorbidities, rather than merely weight loss. Patient education surrounding the role of exercise in the process should be part of future randomized trials to test and promote increased physical activity before and after bariatric surgery.

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