Obesity Surgery (2020) 30:1118–1125
https://doi.org/10.1007/s11695-020-04390-x

REVIEW

# Towards Optimized Care After Bariatric Surgery by Physical Activity and Exercise Intervention: a Review

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Published online: 8 January 2020


## Abstract

Although there is growing evidence on the importance of physical activity and exercise intervention after bariatric surgery, it remains to be clarified as to why and how post-operative exercise intervention should be implemented. In this narrative and practically oriented review, it is explained why exercise interventions and physical activity are important after bariatric surgery, how to prescribe exercise and monitor physical activity and how and when physical fitness, muscle strength, fat (-free) mass and bone mineral density could be assessed during follow-up. It is suggested that the inclusion of physical activity and exercise training in the clinical follow-up trajectory could be of great benefit to bariatric surgery patients, since it leads to greater improvements in body composition, bone mineral density, muscle strength and physical fitness.

**Keywords** Bariatric surgery · Physical activity · Exercise training · Body composition · Muscle strength · Endurance capacity · Bone mineral density

## Background

Based on 2016 WHO statistics, 39% and 13% of adults on global scale are overweight or obese, respectively. Especially the observed trends in children and adolescents are worrisome [1]. Because it is well known that childhood obesity very often leads to obesity in adulthood, a 33% increase in the obesity prevalence and a 130% increase in the severe obesity prevalence is anticipated between 2010 and 2030 in the USA [2]. The obese state makes individuals prone to the development

**Electronic supplementary material** The online version of this article (https://doi.org/10.1007/s11695-020-04390-x) contains supplementary material, which is available to authorized users.

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of many chronic diseases and difficulties [3], which often leads to more absenteeism at work and an increased healthcare consumption (~ 42% higher) [4–6]. On the other hand, reducing the average adult body mass index (BMI) by 5% could save $30 billion in 5 years and up to $612 billion in 20 years, according to data from the USA [7].

Unfortunately, the long-term impact of a lifestyle intervention (combination of caloric intake restriction and increase in physical activity) is often disappointingly small in patients with obesity [8]. Bariatric surgery, on the other hand, is highly effective to reduce body weight in these patients: the 12-month excess weight loss for laparoscopic vertical sleeve gastrectomy ranges from 70 to 83%, and for laparoscopic Roux-en-Y gastric bypass from 60 to 86% [9]. However, after this initial period of fast weight loss, in some patients, a significant weight regain and other long-term adverse effects can be seen [10].

Therefore, guidelines have been published stipulating how to execute post-bariatric follow-up to optimize patient outcomes, including a close follow-up of the glycaemic control, blood lipid profile, obstructive sleep apnoea, gastroesophageal reflux disease, body weight, quality of life, the nutritional state, eating behaviour and bone health [11]. However, a close inspection of these guidelines reveals that the role/importance of physical activity or exercise intervention in the post-bariatric follow-up trajectory is mentioned to a limited extent [11]. However, an increase in physical activity or the implementation of an exercise intervention seems a viable add-on therapy in patients who underwent bariatric surgery [12–21]. Moreover, a significant proportion of patients do not achieve an increase in physical activity after bariatric surgery [21, 22].

Therefore, the aim of this narrative review is to (1) summarize the beneficial impact of physical activity or exercise intervention after bariatric surgery, (2) provide tools on how clinicians could assess physical activity and targeted components of health by such interventions and (3) discuss exercise program characteristics (frequency, intensity, time and type) that are likely to result in better health outcomes in these patients.

## Literature Search Methodology

Although this was not a systematic review, literature was scanned methodologically independently by the first two authors. In Supplementary Table 1, the used MESH terms and key words are mentioned. English literature was scanned on PubMed and Web of Science up to November 2019. Papers were selected based on their level of evidence, preferentially from highest to lowest priority: practice guideline or position statement, meta-analysis, systematic review, randomized controlled trial, prospective observational trial. Retrospective studies, narrative reviews and case studies were not considered. Moreover, articles in other languages than English were not considered either.

## Importance of Physical Activity and Exercise Intervention After Bariatric Surgery

Physical activity increases total energy expenditure and leads 1 year after bariatric surgery to a 4.2% greater BMI reduction and prevents weight regain within the first 2 years [23]. In addition, such interventions leads to a better preservation of muscle strength, muscle mass, endurance capacity, and bone mineral density, and a greater quality of life as will be discussed in the following paragraphs [24–27]. In final, in patients with obesity or other chronic diseases, physical activity levels independently relate to a lower risk for premature death, complications, need for hospitalization and other healthcare consumptions [28, 29].

A greater physical fitness relates to a better prognosis and (disability-free) life expectancy in many different cohorts of patients and in healthy individuals [30]). The physical fitness actually is prognostically more important than adiposity in obese individuals [31]. After bariatric surgery, the functional capacity (as assessed by the 6-min walking test (6MWT)) or self-reported physical fitness increases significantly [32, 33]. However, this does not indicate that the exercise capacity (as preferentially assessed by ergospirometry to measure peak oxygen uptake ($VO_{2peak}$)) is actually improved. On the contrary, significant reductions in $VO_{2peak}$ (as expressed in l/min), or a lack of increments in this parameter, are observed after bariatric surgery [27, 34, 35].

A muscle strength decline independently translates into a greater risk for premature death and loss of independence [36]. As result of bariatric surgery, 10–28% of the total body weight loss is attributed to decrements in muscle mass [37, 38]. Moreover, a study found that the prevalence of sarcopenia rose from 8% up to 32% within 1 year after sleeve gastrectomy [39]. When significant reductions in muscle strength are observed in association with significant reductions in functional capacity/exercise capacity [40] (as observed during exercise tests), clinicians could examine in greater detail whether severe muscle wasting is occurring and intervene accordingly. After all, muscle wasting or (in a more advanced stage) obesity sarcopenia is independently associated with various adverse outcomes (leading to a 24% higher risk for premature death) [41]. Moreover, bariatric surgery leads to significant reductions in bone mineral density, thus elevating the risk for bone fractures [42–44].

As a result, in the follow-up of patients after bariatric surgery, the assessment of physical activity and fitness, muscle strength and mass, and mineral bone density could be considered by clinicians. In addition, interventions aiming to improve these outcome parameters lead to a better preservation of muscle strength, muscle mass, endurance capacity, bone

**Table 1** How to assess additional clinical parameters after bariatric surgery

| What could be assessed | How to assess | Interpretation |
|---|---|---|
| Physical activity | Prefer accelerometers | Accelerometer [45–47]:<br>− Sedentary time = < 100 counts per minute (cpm)<br>− Light physical activity (LPA) = 100–1951 cpm<br>− Moderate PA (MVPA) = 1952–5724 cpm<br>− Vigorous PA (VPA) = > 5724 cpm |
| | Pedometers can be used alternatively | Pedometer [45–47]:<br>- < 5000 steps/day: 'sedentary lifestyle'<br>- 5000–7499 steps/day: 'low active'<br>- 7500–9999 steps/day: 'somewhat active'<br>- > or = 10,000 steps/day: 'active'<br>- >12,500 steps/day: 'highly active' |
| | Use of questionnaires is discouraged | |
| Physical fitness | Prefer ergospirometry | Calculate predicted normal $VO_{2peak}$ on bike by [48]:<br>For men 4.97 l/min (0.033 × age in years)<br>For women 3.31 l/min (0.022 × age in years)<br>Add 10–20% of this $VO_{2peak}$ if the exercise test is executed on a treadmill [49].<br>A $VO_{2peak}$ corresponding to 100% of the normal value (at a respiratory gas exchange ratio (RER) ≥ 1.10) is considered normal, but significantly reduced when being < 75% of the normal value [50]. |
| | Alternative field test: aerobic power index test [51] | The protocol consists of pedalling at 25 W for 1 min on a bike, while increasing this power output by a further 25 W every subsequent minute until the patient reaches his/her target heart rate (the target heart rate (THR), as calculated by: 220 − age × 0.75). |
| | 6-min walking test can be used to assess functional capacity [52] | The test should be performed indoors or outdoors (in good weather), along a long, flat, straight, enclosed corridor with a hard surface. The walking course must be at least 30 m in length. The turnaround points should be marked with a cone. The observer should walk behind the patient, providing a standardized verbal encouragement and test time indication every single minute. Walking aids (when used in daily life) are allowed to be used during this test. The total walking distance after 6 min is noted and compared with normal values [53]:<br>For men = (7.57 × height in cm) − (5.02 × age) − (1.76 × weight in kg) − 309 m<br>For women = (2.11 × height in cm) − (2.29 × weight in kg) − (5.78 × age) + 667 m<br>This test can also be executed on treadmill when a corridor is not available, with zero inclination [54]. The patient begins walking at a speed of 3 km/h and is encouraged to walk as far as possible [55] and is allowed to change the speed of the treadmill any time, or interrupt the test. The total distance walked can then be used as outcome measure. |
| Body composition | Dual x-ray absorptiometry scan is preferred | Assess lean tissue mass of arms and legs and calculate appendicular muscle mass (AMM) by: lean body mass − bone mass. Next, divide AMM by body length$^2$ and compare with following reference values [56]:<br>≥ 7.26 kg/m$^2$ (men)<br>≥ 5.5 kg/m$^2$ (women) |
| | Alternatively, bioelectrical impedance weighing can be executed | Patient should be preferentially in a fasted state (for at least 8 h) and should not have consumed alcohol for at least 48 h [57]. The bladder should be voided and strenuous physical exercise should be avoided for at least 48 h. It is advised to use electricity-isolating material (e.g. towel) between the arms and trunk and between the thighs. |
| | Waist circumference should be assessed | Measured with a non-elastic tape measure while the patient is standing and at end of normal expiration [57]. The WC should be measured half way between the iliac crest and the lowest rib [58]. |
| Muscle strength | Dynamometry is the gold-standard method | Measure maximal isokinetic and isometric muscle strength of major muscle groups and compare with published reference values [59]. |
| | Alternatively, a 1-repetition maximum test can be executed | The patient should execute a warm-up with light weights (at least five repetitions). Next, an arbitrary (but heavier) weight is selected, after which the patient is requested to execute as many correct contractions possible (taking 2–3 s from starting to end position). The total number of repetitions (preferentially < 10) is noted, by which the 1RM can be estimated by [60]):<br>1RM (in kg) = (0.33 × repetitions) × applied weight + applied weight |

mineral density and a greater quality of life as will be discussed in the following paragraphs [24–27].

## How to Assess and Monitor Physical Activity and Health-Related Fitness (Table 1)

A discrepancy can be observed between changes in self-reported physical activity (by physical activity questionnaires) after bariatric surgery where significant improvements are noticed in most studies, while in studies assessing physical activity by means of objective tools (i.e. step counter or accelerometry), a significant amount of patients do not increase their physical activity level [32]. If the aim of the healthcare provider is to assess physical activity, questionnaires seem less suitable in this population (due to over-reporting or not being able to define what is low-, moderate- or high-intense exercise) [61]. Not all pedometers are capable of measuring exercise intensity and at a low walking pace, pedometers lack accuracy to detect steps. As post-bariatric surgery patients still walk at significantly slower self-selected paces, thus leading to lower elicited exercise intensities in daily life [62, 63], less accurate registration by pedometers might occur [54]. Therefore, accelerometry is preferred to objectivize physical activity [32, 54, 61–63]. A step counter or (preferentially) accelerometer should be enclosed in a case and typically attached to the hip (or lower back) by a strap with the device in horizontal position.

Improvements in walking capacity appear to be a mechanical phenomenon attributable largely to the weight loss achieved, as opposed to absolute improvements in cardiorespiratory or muscular function [55]. Therefore, the risk of poor cardiorespiratory and muscle function may remain present in patients after bariatric surgery, despite seeming improvements in walking capacity. To understand the impact of surgery on daily life functioning, a functional capacity test could be selected as well, such as the 6MWT [52]. The 6MWT can also be executed on a treadmill when a corridor is not available. However, it remains uncertain whether this value may be compared with normal values for the 6MWT [52, 53]. As a result, the 6MWT in corridor should be preferred. In a significant number of (formerly) obese patients, musculoskeletal symptoms are present during walking activities [64]. In this regard, it is relevant to assess whether these symptoms change during the weight loss period: changes in these symptoms will affect the 6-min walking capacity.

When it is aimed to assess exercise capacity, it is advised to monitor $VO_{2peak}$ (in l/min) and also not to further divide this $VO_{2peak}$ by body weight (as ml/min/kg), as also in this case, changes in body weight will bias the interpretation. Therefore, dividing $VO_{2peak}$ by fat-free mass should be considered. Once a normal body weight is achieved, on the other hand, $VO_{2peak}$ could be divided by body weight for long-term follow-up and estimation of prognosis. When the direct assessment of $VO_{2peak}$ is not possible, field tests can be used, such as the aerobic power index (API) test [51]. The achieved cycling power output can then be followed up to quantify changes in physical fitness. However, this test cannot be used when HR lowering medications are used (beta-blockers and certain calcium antagonists).

For a fast evaluation of muscle strength, handgrip strength may be proposed. However, it has been shown that the handgrip strength test is not sensitive enough to measure changes in strength after bariatric surgery, thus limiting its clinical relevance during follow-up [65]. Therefore, muscle groups that are targeted during the exercise intervention, or are clinically relevant for daily life activities, should best be individually assessed. Moreover, when aiming to study changes in muscle strength, the biasing impact of changes in body weight during these tests should best be avoided (making strength tests in which their own body weight is involved invalid). In the hospital setting, dynamometry testing (e.g. Biodex or Cybex) can be executed. In the non-hospital setting, it is advised to estimate the 1-repetition maximum (1RM) of leg press, lateral pull-down and chest press (to assess upper and lower extremity muscles), for which valid formulae are available to calculate 1RM from submaximal contractions with the same weight [60]. This 1RM is useful for training intensity (i.e. load) prescription and for the evaluation of changes in muscle strength over time.

At last, body composition is directly related to exercise capacity, and to monitor changes in lean tissue mass and bone mineral density, a dual x-ray absorptiometry scan is proposed. However, when clinicians do not have access to such a scan, tetrapolar bioelectrical impedance analysis may be used, as sufficiently high correlations were observed with dual x-ray absorptiometry scan ($r = 0.87$, 0.82 and 0.99 at baseline, 6 months and 12 months of follow-up, respectively), under the assumption that the patient is normo-hydrated [66]. However, bioelectrical impedance analysis does not allow a sufficiently detailed analysis of where changes in fat mass occur and in bone mineral density. Furthermore, any medical condition that leads to alterations in hydration status (e.g. heart failure, renal insufficiency, venous or lymphatic disease) may interfere with estimations of fat mass. Additionally, as abdominal fat mass is related to worse outcomes, assessment of the waist circumference can be indicated.

Current clinical guidelines stipulate that patients undergoing bariatric surgery should be treated/followed in a multidisciplinary setting (including surgeon/physician, nurse, pharmacist, dietician, psychologist), and a specific assessment should be executed [11]). By the additional assessment of physical activity, physical fitness, muscle strength and bone health, an optimized follow-up can be established.

## Physical Activity Intervention After Bariatric Surgery: What Can We Do (Table 2)?

How to exercise after bariatric surgery, with the aim to positively affect the different health-related physical fitness components, is not mentioned in much detail in current clinical guidelines [11]. It thus follows that this may lead to a suboptimal clinical follow-up. Such tailoring of exercise prescription is however important and is, for example in cardiovascular rehabilitation, the state of the art [50, 67]. Exercise intervention should thus best be designed to specifically affect fat mass, muscle mass, endurance exercise capacity and bone mineral density in patients who have underwent bariatric surgery.

Growing evidence supports the benefits of structured/supervised exercise intervention in physical activity–related enjoyment, self-efficacy, motivation, functional muscle strength, walking capacity, $VO_{2peak}$, insulin sensitivity, body weight, skeletal muscle mitochondrial respiration capacity and preservation of bone mineral density, in post-bariatric patients, as opposed to usual-care follow-up [12–21]. Exercise intervention therefore has much potency in the care of patients undergoing bariatric surgery.

A pre-operative start-up of exercise training could lead to a greater adherence to post-operative exercise intervention and post-operative clinical benefits [68–70]. In the pre-operative phase, it is advised to provide an introduction to exercise training. In this regard, low-intense endurance exercise and low-intense strength training should be executed 2–3 days/week for several weeks preceding the surgical intervention. Such pre-operative intervention leads to greater adherence to exercise guidelines, BMI reductions and physical fitness/muscle strength in the first year after surgery [70].

In the post-operative phase, significantly greater health benefits are ambitioned: a greater fat mass reduction, the preservation of muscle mass and bone mineral density, the preservation or improvements in muscle strength, and improvements in $VO_{2peak}$ (endurance capacity). In this regard, the following exercises are suggested, based on available evidence [71]. Increase the weekly endurance exercise volume significantly and achieve a permanently (life-long) increased physical activity level. It is noticed that exercise or physical activity with smaller total exercise volumes actually fail to maximize weight loss after surgery [72]. It is advised to permanently increase daily physical activity (non-structured physical activity) next to supervised exercise training (structured physical activity) to minimize body weight regain. To sustain these high exercise training volumes and to maximize total caloric expenditure during exercise training, moderate-intense endurance exercises involving large muscle groups could be preferred, and the patient should exercise sufficiently frequent. The addition of moderate-to-high-intense strength exercises for large muscle groups is highly relevant to these patients. To stimulate muscle mass gain or acquire a better preservation of lean tissue mass, it can also be advised to combine strength training with sufficient intake of proteins and amino acids [73, 74].

The long-term adherence to physical activity guidelines may be problematic in a significant proportion of patients after bariatric surgery. Although it remains to be studied in patients who underwent bariatric surgery, telemonitoring and exercise followed up by telemonitoring systems in cardiovascular disease is highly effective to preserve the physical activity [75, 76].

## Future Perspectives

While several studies have examined the effect of endurance exercise after bariatric surgery, little is known about the effect of resistance/strength training [77, 78]. Moreover, most studies evaluated endurance training of moderate-intensity confirming its beneficial effects after bariatric surgery. However, future research should examine whether isocaloric exercise interventions at higher intensity may elicit additional weight loss or positively affect body composition or regional/ectopic adiposity (visceral or hepatic fat) [79]. As uptake and long-term adherence to an active lifestyle are crucial for long-term beneficial effects, future research should look into the use of telemonitoring or the adoption of lifestyle applications to

**Table 2** How to exercise before and after bariatric surgery

| Timing | Endurance exercise | Resistance exercise | Additional measures |
|---|---|---|---|
| Before surgery | 20–45 min/session, 45–54% peak heart rate or 10–11 Borg ratings of perceived exertion (RPE) scale), 2–3 days/week | < 60% of 1-repetition maximum (1RM), 12–15 repetitions, ≥ 6 muscle groups, 3 series/large muscle group, 2–3 days/week | None |
| After surgery | Weekly endurance exercise volume up to 250–400 min, moderate effort (55–70% peak heart rate, Borg RPE 12–14), involving large muscle groups (e.g. walking, stepping, rowing, cross-training), from 3 up to 5 days per week | Moderate-to-high-intense resistance exercises (≥ 70% of 1RM), 12–15 repetitions for 3 series each exercise, targeting large muscle groups (e.g. m. quadriceps femoris, hamstrings, calfs, abdominal and back muscles, m. biceps brachi, m. triceps brachi, shoulder muscles) | Minimize sedentary time and stimulate habitual activity, ensure 60–120 g/day of protein and amino acids (especially leucine) intake |

increase levels of physical activity. Future research should also look into the ideal physical activity interventions after bariatric surgery in adolescents, as this is an age group which is growing. Due to current restrictions in reimbursement policies and/or logistic limitations, some advices mentioned in this paper cannot be achieved (yet). However, the current evidence collectively indicates that care after bariatric surgery could be improved significantly by the additional incorporation of health-related fitness components assessments and physical activity and exercise interventions.

## Conclusion

Current clinical guidelines provide specific recommendations in the follow-up and care of patients who underwent bariatric surgery. This review elaborates more specifically on physical activity and exercise intervention in order to further improve post-operative health benefits in terms of changes in body weight and fat mass, muscle mass and strength, physical fitness and bone mineral density.

### Compliance with Ethical Standards

**Conflict of Interest** Author 1 received personal fees from Johnson & Johnson, but this did not affect the content of this manuscript and was not in support of the preparation of this manuscript.

Author 2 is a scientific affairs consultant for Pro Well, but this did not affect the content of this manuscript. Author 3 is the general manager of Pro Well, but this did not affect the content of this manuscript.

Author 4 received personal fees from Johnson & Johnson, Olympus, MID and Gore, but this did not affect the content of this manuscript and was not in support of the preparation of this manuscript.

Author 6 received personal fees from Johnson & Johnson and Medtronic, but this did not affect the content of this manuscript and was not in support of the preparation of this manuscript.

Authors 5 and 7 have nothing to declare.

**Human/Animal Rights Statement** This article does not contain any studies with human participants or animals performed by any of the authors.

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