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EFFICACY OF ENDURANCE VERSUS STRENGTH EXERCISE TO INCREASE THE FUNCTIONAL CAPACITY OF OBESE PEOPLE AFTER BARIATRIC SURGERY: A SYSTEMATIC NARRATIVE REVIEW

EFICÁCIA DO EXERCÍCIO DE RESISTÊNCIA VERSUS FORÇA PARA AUMENTAR A CAPACIDADE FUNCIONAL DE PESSOAS OBESAS APÓS A CIRURGIA BARIÁTRICA: UMA REVISÃO NARRATIVA SISTEMÁTICA

EFICACIA DEL EJERCICIO DE RESISTENCIA VERSUS FUERZA PARA AUMENTAR LA CAPACIDAD FUNCIONAL DE PERSONAS OBESAS DESPUÉS DE LA CIRUGÍA BARIÁTRICA: UNA REVISIÓN NARRATIVA SISTEMÁTICA

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ABSTRACT

Introduction: Obesity has emerged as a global health concern, forcing researchers, policymakers, and healthcare professionals to join forces to combat this multifaceted epidemic. Increasing your level of physical activity is part of your treatment. However, it is not clear which exercise is most suitable.

Objective: Synthesize evidence on which type of exercise is most effective on the functional capacity of obese people after bariatric surgery.

Methods: Systematic review of randomized clinical trials published in English, Spanish and Portuguese. We searched from April 23 to June 10, 2023 in the MedLine databases via PubMed, Latin American and Caribbean Literature in Health Sciences (LILACS), Excerpta Medica dataBASE (EMBASE), gray literature and the Cochrane Library. We analyzed risk of bias with the Revised Cochrane tool (Rob 2) and certainty of evidence and strength of

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recommendation with the Recommendation Rating Assessment, Development and Evaluation system.

Results: Of the 10,436 publications identified, we included 6 studies, with a population of 175 obese people, mostly women, aged between 18 and 65 years undergoing gastric bypass. The studies were published from 2011 to 2018 in Brazil, Canada, USA, Iran and the United Kingdom. Our synthesis and analysis demonstrated, with a low level of confidence, that resistance exercises, isolated or combined with strength exercises, were more effective in the functional capacity of obese people after bariatric surgery.

Conclusion: With a weak recommendation and low level of evidence, we recommend that resistance exercises be used for functional capacity in obese patients after bariatric surgery.

Keywords: Functional Capacity. Bariatric Surgery. Exercise. Obesity.

RESUMO

Introdução: A obesidade surgiu como uma preocupação global de saúde, levando pesquisadores, formuladores de políticas públicas e profissionais da saúde a unirem esforços para combater essa epidemia multifacetada. O aumento do nível de atividade física faz parte do tratamento; entretanto, ainda não está claro qual tipo de exercício é o mais adequado.

Objetivo: Sintetizar as evidências sobre qual tipo de exercício é mais eficaz para a capacidade funcional de pessoas obesas após a cirurgia bariátrica.

Métodos: Revisão sistemática de ensaios clínicos randomizados publicados em inglês, espanhol e português. A busca foi realizada entre 23 de abril e 10 de junho de 2023 nas bases de dados MedLine via PubMed, Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), Excerpta Medica dataBASE (EMBASE), literatura cinzenta e na Cochrane Library. O risco de viés foi analisado com a ferramenta Revisada da Cochrane (Rob 2) e o nível de evidência e força de recomendação foram avaliados pelo sistema GRADE (Grading of Recommendations Assessment, Development and Evaluation).

Resultados: Das 10.436 publicações identificadas, foram incluídos 6 estudos, com uma população de 175 pessoas obesas, em sua maioria mulheres, com idades entre 18 e 65 anos, submetidas ao bypass gástrico. Os estudos foram publicados entre 2011 e 2018 no Brasil, Canadá, Estados Unidos, Irã e Reino Unido. Nossa síntese e análise demonstraram, com baixo nível de confiança, que os exercícios de resistência, isolados ou combinados com exercícios de força, foram mais eficazes para melhorar a capacidade funcional de pessoas obesas após a cirurgia bariátrica.

Conclusão: Com uma recomendação fraca e baixo nível de evidência, recomenda-se o uso de exercícios de resistência para melhorar a capacidade funcional de pacientes obesos após a cirurgia bariátrica.

Palavras-chave: Capacidade Funcional. Cirurgia Bariátrica. Exercício. Obesidade.

RESUMEN

Introducción: La obesidad ha surgido como una preocupación mundial de salud, lo que ha llevado a investigadores, responsables de políticas públicas y profesionales de la salud a unir fuerzas para combatir esta epidemia multifacética. El aumento del nivel de actividad física forma parte del tratamiento; sin embargo, no está claro qué tipo de ejercicio es el más adecuado.

Objetivo: Sintetizar la evidencia sobre qué tipo de ejercicio es más eficaz para la capacidad funcional de las personas obesas después de la cirugía bariátrica.

Métodos: Revisión sistemática de ensayos clínicos aleatorizados publicados en inglés, español y portugués. La búsqueda se realizó entre el 23 de abril y el 10 de junio de 2023 en las bases de datos MedLine vía PubMed, Literatura Latinoamericana y del Caribe en Ciencias de la Salud (LILACS), Excerpta Medica dataBASE (EMBASE), literatura gris y la Cochrane Library. El riesgo de sesgo se analizó con la herramienta Revisada de Cochrane (Rob 2) y el nivel de evidencia y la fuerza de la recomendación se evaluaron con el sistema GRADE (Grading of Recommendations Assessment, Development and Evaluation).

Resultados: De las 10.436 publicaciones identificadas, se incluyeron 6 estudios, con una población de 175 personas obesas, en su mayoría mujeres, con edades entre 18 y 65 años, sometidas a bypass gástrico. Los estudios fueron publicados entre 2011 y 2018 en Brasil, Canadá, Estados Unidos, Irán y Reino Unido. Nuestra síntesis y análisis demostraron, con un bajo nivel de confianza, que los ejercicios de resistencia, aislados o combinados con ejercicios de fuerza, fueron más eficaces para mejorar la capacidad funcional de las personas obesas después de la cirugía bariátrica.

Conclusión: Con una recomendación débil y bajo nivel de evidencia, se recomienda el uso de ejercicios de resistencia para mejorar la capacidad funcional de los pacientes obesos después de la cirugía bariátrica.

Palabras clave: Capacidad Funcional. Cirugía Bariátrica. Ejercicio. Obesidad.

1 INTRODUCTION

In recent decades, the relentless rise in obesity rates has reached epidemic proportions, becoming one of the most significant public health challenges of our time[45]. The World Health Organization (WHO) estimates that more than 650 million adults worldwide were affected by obesity in 2016, burdening healthcare systems with excessive costs, inhibiting productivity, and exacerbating health inequalities in societies[45]. The implications of this epidemic are severe and profound, contributing to a wide range of debilitating health conditions[6,38]. These include cardiovascular disease, diabetes, musculoskeletal disorders, hyperlipidemia, hypertension, obstructive sleep apnea, asthma, various forms of cancer and depression, and comorbidities responsible for more than 2.5 million premature deaths annually worldwide[43]. Adults with obesity incur 42% higher per capita medical costs and are nearly twice as likely to die before age 70 than adults at a healthy weight.

Defined as the excessive or abnormal accumulation of body fat, this complex condition arises from many factors that lead to an imbalance between caloric intake and expenditure[44]. Changes in eating patterns, particularly the consumption of energy-rich and nutrient-poor foods, rich in sugars and saturated and trans fats; inaccessible healthy foods, and accessibility to unhealthy products; psychological and behavioral factors, including high levels of stress, emotional eating, and lack of sleep; genetic factors influencing appetite control, metabolism, and fat storage; sedentary lifestyle and reduced levels of physical activity, arising from technological advances and changes in social and work environments[14]. Therefore, as a complex and multifactorial health condition, obesity requires a comprehensive, complex, and multifactorial approach[30].

Its treatment encompasses several therapeutic modalities ranging from lifestyle modifications to pharmacotherapy and surgical interventions, especially in cases of severe obesity[30]. Lifestyle modifications, including dietary changes, exercise programs, and behavioral counseling, are the cornerstone of obesity management[32]. Pharmacotherapy can be considered in cases where lifestyle modifications are insufficient, employing medications that control appetite, fat absorption, or metabolism[44]. In extreme cases of severe obesity, body mass index (BMI) > 40 kg/m^2 or BMI > 35 kg/m^2 in the presence of essential comorbidities, and when other treatments fail to induce weight loss, bariatric surgery becomes an option, significantly reducing the capacity of the stomach or altering its function, leading to substantial weight loss and reducing obesity-related comorbidities, which also reduces the risk of early death[17,23,33].

Functional capacity refers to individuals' ability to carry out tasks and activities they consider necessary or desirable. It is often assessed through cardiorespiratory fitness, which reflects the anatomical and physiological integrity of the respiratory, cardiovascular, and skeletal muscle systems[40]. This capacity is reduced in obese individuals, either because of the disease itself or due to a sedentary lifestyle before and after surgery[36]. Even after surgery, managing this complex health condition is still crucial for maintaining the positive outcomes obtained with surgery, such as adequate weight, functional capacity, and quality of life, ensuring the success of the surgery in the long term[22,26,31]. However, most patients awaiting bariatric surgery are inactive before surgery[7,43]. Despite enormous weight loss and a slight improvement in physical activity level during the first year after surgery, most remain inactive after bariatric surgery[4,5,27].

Physical exercise is considered an intervention that reduces overall morbidity and mortality and is widely recognized as a fundamental component of post-bariatric surgery care[3,4]. It promotes the maintenance of weight loss, improves physical fitness and functional capacity, and reduces the risk of comorbidities[3]. However, different types of exercise provide different results, and the ideal exercise to maximize post-surgical results remains a topic of ongoing debate.

Although there are individual studies with valuable information, most focus on post-surgery weight loss, while issues related to functional capacity remain unclear. As such, a comprehensive synthesis of existing literature is needed to clarify current knowledge gaps and provide robust evidence to inform clinical practice. Based on the above, the guiding question of this study was: is there a type of exercise that is more effective in increasing the functional capacity of obese individuals after bariatric surgery?

2 METHODS

2.1 EXPERIMENTAL APPROACH TO THE PROBLEM

To answer the research question, we performed a systematic review of randomized controlled trials, following the methodological recommendations of the Cochrane Collaboration Handbook, and reported by the Preferred Reporting Items for Systematic Reviews statement[23]. We used the PRISMA method flowchart to present the number of studies identified in the searches[35].

The study protocol was published in PROSPERO (CRD42023401411)[42].

2.2 ELIGIBILITY CRITERIA

We included randomized clinical trials in English, Portuguese, and Spanish, published until June 10, 2023, which compared endurance exercise with resistance exercise, or a combination of both, in obese people after bariatric surgery, with the primary objective of increasing/maintaining Functional capacity. Our secondary objective was to evaluate exercise volume and intensity.

We excluded studies that did not address the research question, incomplete articles, abstracts, review articles, expert opinions, editorials, books, academic works, dissertations, theses, proceedings of scientific events, articles not available online, and studies carried out on animals.

2.3 SEARCH STRATEGY AND INFORMATION SOURCES

We performed a comprehensive search strategy in the electronic databases MedLine via PubMed, Latin American and Caribbean Literature in Health Sciences (LILACS), Excerpta Medica dataBASE (EMBASE), gray literature, and Cochrane Library. We used descriptors and correlates found in the Medical Subject Heading (MeSH) and descriptors in Health Sciences (DeCS) for the search: Adult, Obesity, Obesity Morbid, Bariatric Surgery, Exercise, Endurance Training, Resistance Training, Exercise Therapy, Exercise Movement Techniques, High-Intensity Interval Training, Circuit-Based Exercise, Physical Fitness, and Physical Functional Performance combined using the Boolean operators "AND" and "OR" as shown in Figure 1.

During the search, we used the following filters: language (English, Portuguese, and Spanish) and type of study (human studies only).

Flowchart of the search strategy with Boolean descriptors and operators (Figure 1)

2.4 STUDY SELECTION AND DATA EXTRACTION

We conducted the selection process independently with two health reviewers and divided it into phases; if there was a disagreement, a third reviewer was consulted. The phases were:

1. Identification: we searched the databases using descriptors and filters and excluded duplicates.
2. Selection: the section where we read the titles and abstracts.

We used Qatar Computing Research Institute's Rayyan QCRI online software for Data Analysis in phases 1 and 2.

3. Eligibility: in which we completed a reading of the studies sought for selection based on the eligibility criteria.
4. Inclusion: in which we extracted the relevant characteristics of each study such as author/year, study country, sample number, study objective, inclusion criteria,

intervention, intervention implementation time, analyzed variables, evaluation instrument, primary outcome, secondary outcome, and study result.

We created a specific form with the excluded studies and the reasons for exclusion (Appendix 1).

2.5 OUTCOME VARIABLES ANALYZED

- Primary outcome: Functional capacity
- Secondary outcome: Exercise volume and intensity

2.6 DATA MANAGEMENT

We used the online software Rayyan QCRI36 from the Qatar Computing Research Institute for data analysis to remove duplicates and read titles and abstracts[34]. To manage bibliographic references, we used Mendeley Desktop software, version 1.19.8[16].

2.7 BIAS ASSESSMENT, QUALITY OF EVIDENCE, AND STRENGTH OF RECOMMENDATION

The methodological quality of the included studies was assessed by two reviewers using the Cochrane Risk of Bias tool for randomized controlled trials (RoB 2.0)[3,18]. If necessary, a third senior reviewer would be called.

We assessed the quality of studies with the Grading of Recommendations Assessment (GRADE)[18], classifying the evidence and strength of the recommendation.

3 RESULTS

3.1 SELECTED STUDIES

The search in the Embase, PubMed, and Cochrane databases resulted in 10436 studies. The other databases did not result in studies. After removing 338 duplicates, 9460 studies were classified as ineligible, and 638 articles remained eligible for selection. After reading the titles and abstracts, 630 studies were not eligible, leaving eight studies to be read in full. Of these, two studies were excluded, one because it was an observational study and the other because it was a study protocol. In the end, we included six studies in qualitative synthesis[9,20,21,25,41,44], as presented in the Prisma flowchart presented in Figure 2.

Appendix 1 presents the excluded studies with the reasons for exclusion.

Study selection flowchart (Figure 2)

3.2 CHARACTERISTICS OF THE INCLUDED STUDIES

All studies included in this systematic review were single center randomized clinical trials related to the primary outcome, which was functional capacity in obese patients after bariatric surgery[9,20,21,25,41,44]. Other outcomes were also analyzed, such as physical activity level, heart rate variability (HRV), quality of life, weight loss, and body composition. The main characteristics of the studies included in the systematic review are presented in Table 1.

All studies included in this systematic review were related to the primary outcome, which was functional capacity in obese people after bariatric surgery. However, other outcomes were also analyzed, such as the level of physical activity[41], heart rate variability (HRV)[9,21], quality of life[41], weight loss[20,25,44] and body composition[20,25,44].

The studies were published in 2011[20,21,41], 2013[9], 2017[25,44] and 2018[41]. Two studies were from Brazil[9,21], one was from Canada[41], one from the United States of America[20], one from Iran[25], and one from the United Kingdom[44].

The total population of the included studies totaled 175 obese people after bariatric surgery (BS), the majority of whom were women, with ages ranging from 18 to 65 years. The sample size was small in all studies, ranging from 21 to 49 participants. The type of bariatric surgery covered in the studies was gastric bypass[9,20,21,25,41], vertical band[41] and gastric band[21,25].

Most studies[9,20,21,41] used a maximum effort test on a treadmill to assess functional capacity, the six-minute walk test (6MWT) was used in some studies[9,20,21,41], one study[25] used the twelve-minute walk test and one study[44] used the incremental shuttle walk test (ISWT).

Most studies[9,20,41,44] were two-arm clinical trials, and two studies had multiple comparisons with 3 arms[21,25]. The comparison measures used in the included clinical trials were: endurance exercise, strength exercise, endurance exercise combined with strength exercise, and standard routine of usual care. One hundred percent of the included clinical trials used a comparison between endurance exercise and usual care[9,20,21,25,41,44], and fifty percent of the studies[25,41,44] combined endurance exercise with strength exercise in their protocols. Two studies[41,44] used endurance exercise combined with strength exercise, comparing it with the usual standard care routine. However, one study[41] applied the exercise protocol before bariatric surgery. Three studies[9,20,21] used the endurance exercise protocol compared to the usual follow-up care routine. Only one three-arm study[25] used two different exercise protocols and the standard usual care routine for comparison (endurance x endurance + strength; endurance x usual care; endurance + strength x usual care).

Regarding the interventions, the endurance exercise instituted in the studies varied in how it was carried out, with the majority using ergometric treadmill walking[9,20,21,41,44]. It was also used for endurance training walking circuit[41], cycle ergometers[20,41], elliptical[41], rowing machine[20], walking outdoors[20,25] or on the track[41], and dancing[41]. In all supervised studies, sessions were divided into warm-up (between 5 and 15 minutes), endurance exercise (30 - 45 minutes) and cool-down (5 - 10 minutes). Stretching and breathing training were used in two studies[9,21] to help warm up and/or relax the body. Sessions ranged from 60 to 80 minutes, 3 to 5 times a week[9,20,21,25,41,44].

The intensity of endurance exercise was moderate to intense in the studies, varying in percentage of the maximum volume of oxygen consumed (% VO_{2max})[20], % of the maximum HR or HRreserve (HR_R)[9,41,44], and the perception of effort according to the Borg of 12-14 (6-20)[25,44], being between 55-88% HR_R, 50-70% of maximum HR[9,21,44] and 60-70% VO_{2max}[20].

In studies in which endurance training was associated with strength exercise[21,25,41], the strength exercise was performed after the endurance exercise and the intensity of strength training was 60% of 1RM, in 3 sets of 12 repetitions[21,25,41]. In other words, it is noteworthy that in all protocols that included strength exercise, it was performed in conjunction with endurance exercise. For the strength exercise, dumbbells[41], elastic bands[25,41], medicine balls[41], sticks[41], and leg press[44] were used. Strength training was performed through isotonic exercises, with intensity defined as % of 1 RM.

Only one study[20] analyzed energy expenditure, recommending that individuals in the intervention group spend more than 2000 kcal per week on endurance exercise.

All included studies[9,20,21,25,41,44] compared interventions with usual care. The authors considered group educational sessions as usual care, addressing physical activity, nutrition, and psychological issues.

Due to the very limited number of studies available, the heterogeneity of study protocols and the way in which outcomes were assessed, it was not possible to carry out meta-analyses to evaluate the effect of the interventions. Instead, a narrative synthesis of the included studies will be presented.

Main characteristics of the included studies (Table 1)

3.3 SUMMARY OF STUDIES

Baillot A et al., 2018[41] – The main objective of this two-arm randomized clinical trial was to compare changes from baseline to 1 year after BS in the level of physical activity, physical fitness, barriers to physical activity and quality of life between groups. A small sample (25 participants) of patients undergoing BS, laparoscopic Roux-en-Y gastric bypass or sleeve gastrectomy was analyzed. Participants aged 18 to 65 years, who had a BMI ≥ 35 kg/m2 with comorbidities, or ≥ 40 kg/m2, were randomized into two groups: PreSET group (intervention group) and usual care group (control group).

The authors considered group educational sessions called BMotivated's Club on physical activity (PA) and nutrition and psychological issues as usual care. The exercise intervention consisted of three weekly 80-minute sessions, consisting of 10 minutes of warm-up, 30 minutes of endurance exercise activity at 55 to 85% of heart rate reserve (treadmill, walking circuit, arm cycle ergometer, elliptical, dance/endurance exercise), 20 to 30 minutes of strength exercises with small equipment (dumbbells, elastic bands, medicine balls and sticks), and 10 minutes of cool-down period, with a monthly water aerobics session, which lasted up to 2 weeks before the BS. The intervention group underwent the exercise program 32.6 ± 8.0 weeks before BS (range 27 to 51 weeks), participating in a median of 70 (45-90% of the total recommended exercise sessions), 3 ×/week from PreSET baseline to 2 weeks before BS. There was no control over the number of sessions received by the groups, nor between participants, so both varied. The authors argue that this was due to different waiting times before BS.

Baseline characteristics were compared between groups with Mann-Whitney for scale data or chi-square tests for nominal data, and the authors describe that the groups were homogeneous. Given the number of assessments and missing data (of which there were many), the authors used mixed model analyzes to evaluate the effect of PreSET. The model had the following fixed effects: groups, time and interaction between group and time. For BMI, for convergence reasons, a simplified model was used with an identity matrix multiplied by a scalar as the residual covariance matrix. They performed post hoc tests to see if there were differences between T1 and each of the other times. Normal residual distribution was checked for valid statistical models. The Holm-Bonferroni method was used to adjust *p* values according to the number of comparisons. Physical fitness was assessed before BS and 1 year after BS.

As a result, the number of steps and time spent in light and moderate physical activity were higher in the intervention group 1 year after BS. However, the declared level of physical activity was not significantly different between groups after BS. In contrast, no differences were observed between the groups in relation to the metabolic equivalent rate (MET) obtained with the symptom-limited exercise test. Therefore, there was no difference in functional capacity. The change in 6MWT distance at one year was greater in the intervention group compared to the control group, however, the significant difference disappeared after Holmes adjustments. No other significant differences between groups were observed. No differences were observed between the groups in relation to PA barriers and quality of life.

The intervention group had greater weight loss than the control group and a significantly greater decrease in fat-free mass. However, this was an exploratory result, as it was not the main outcome of the study. No significant differences were observed between groups for changes in other anthropometric measurements (i.e., neck circumference, fat mass) as well as for resting heart rate and blood pressure.

This study had some limitations. The first one was the small sample size. The sample was heterogeneous in relation to its characteristics. Furthermore, the high number of participants excluded because they were unable to attend regular exercise sessions limited the generalization of the results. Another point was the different duration of training between participants. And finally, there is a lot of missing data in the analyses. All of this reduces the internal and external validity of the study.

Castello-Simões V et al., 2013[9] – This randomized clinical trial investigated the effects of aerobic physical training on heart rate variability (HRV) and heart rate kinetics (HR) during submaximal endurance exercise in obese women undergoing gastric bypass surgery. The researchers randomized 19 women with morbid obesity, similar age and anthropometric factors, 9 to a control group (GC) and 10 to a physical training group (GT). Additionally, they recruited 12 women into a group they called the eutrophic group (GE). The primary outcomes were HRV indices and heart rate kinetics during submaximal exercise, which were assessed at baseline and after the 12-week intervention.

The physical training group underwent a supervised endurance exercise program on a treadmill totaling 36 sessions, lasting 60 minutes each, over 12 weeks. The session consisted of 10-minute warm-ups, with stretching, breathing exercises and light walking (3 km/h on a treadmill), 40 minutes of endurance exercises on a treadmill, divided into 4 phases: 1 - 50% maximum HR, 2 - 60% of maximum HR, 3 - 60-70% of maximum HR and 4 - 70% of maximum HR, followed by 1 minute of recovery on the treadmill at 3 km/h and 10 minutes of stretching and breathing exercises.

The results demonstrated a significant improvement in HRV indices, specifically in the square root of the mean of successive differences, in the GT compared to the GC. GT also exhibited faster HR kinetics during submaximal exercise, as indicated by a shorter heart rate recovery time constant (T1/2). The researchers report that obese women showed a reduction in the 6MWT distance compared to controls, and that the TG significantly increased the distance covered when compared to the GC. The authors attributed the better distance covered in the 6MWT to better submaximal exercise performance, related, at least partially, to aerobic activity as it promotes increased ventilatory demand and, over time, greater resistance to fatigue.

There are some limitations to note in this study. First, the study only included a small sample, which may limit the generalizability of the results. The sample was very heterogeneous in relation to its age characteristics, which reduces the internal and external validity of the study.

Shah M et al., 2011[20] – This two-arm randomized clinical trial investigated whether a high-volume exercise program would be effective in weight loss and physical fitness in obese individuals undergoing BS. The researchers randomized 28 post Roux-en-Y gastric bypass and gastric band surgery patients into two groups: a high-volume exercise group (GI) and a control group (GC) for 12 weeks. The GI participated in a structured exercise program consisting of aerobic and strength exercises, while the GC received standard care without any exercise program. The primary outcomes measured in this study were weight loss and physical fitness, which were assessed at 24 weeks and 48 weeks after surgery. The researchers also looked at several secondary outcomes, including body composition, cardiopulmonary fitness, muscle strength and quality of life.

The exercise goal in the GI was to spend ≥2,000 kcal/week on moderate-intensity endurance exercise with 60-70% of maximum oxygen consumption (VO2max). Subjects were instructed to achieve these goals gradually, and were asked to expend 500 kcal during the first week and increase by 500 kcal each week until they reached the goal of ≥2000 kcal/week. Each subject was asked to exercise on the treadmill at a given speed and incline, and on the cycle ergometer or rowing machine at a given speed and incline, with a specific power output that would correspond to 60-70% of their measured VO2max. When exercising elsewhere, they were asked to use equipment and follow the same individualized protocol used at the gym. Participants who preferred walking outdoors or walking on the trail were asked to measure the distance they walked and asked to complete this distance in a period to reach a pace associated with an intensity of 60-70% of measured VO2max. Once the intensity was reached and the subjects became more physically fit, they were asked to increase their intensity to maintain the same level of perceived exertion. Participants were asked to exercise at least 5 days a week. The exercise was partially supervised, and subjects were asked to come to the fitness center at least once or twice a week.

The results of the study showed that the GI had significantly greater weight loss compared to the GC, both 24 and 48 weeks after surgery. The GI also demonstrated improvements in physical fitness, with higher levels of cardiopulmonary fitness and muscular strength compared to the GC. Furthermore, the GI also recorded improvements in body composition, including a reduction in fat mass and an increase in lean mass, which could have further contributed to weight loss. Both groups reported significant improvement in some quality-of-life scales. Changes in weight, energy and macronutrient intake, resting energy expenditure, fasting lipids and glucose, and postprandial and fasting insulin concentrations were not different between the two groups.

The study has certain limitations to be considered. The high-volume exercise program used in this study may not be feasible or sustainable for all obese individuals, and the results may not be generalizable to all post-bariatric surgery patients. The sample was small and very heterogeneous in relation to its age characteristics, which reduces the internal and external validity of the study.

Castello V et al., 2011[21] – This two-arm randomized clinical trial investigated whether a 12-week endurance exercise program positively impacts HRV and functional capacity after gastric bypass and gastric band surgery in a female cohort.

The study involved obese women undergoing Roux-en-Y gastric bypass surgery, randomized into two groups: GC, with 10 participants and GI (endurance exercise), with 11 participants. The control group did not participate in any structured exercise program, while the exercise group performed aerobic training for 12 weeks.

Each GI session consisted of: (1) 5 initial minutes of stretching the upper and lower limbs (hamstrings, quadriceps, calves, shoulders), diaphragmatic breathing and awareness of proper posture in front of a mirror in standing and sitting positions, (2) followed by 5 min warm-up on a treadmill at 3 km/h, (3) and 40 min of exercise on a treadmill with speed and incline varying according to HR behavior. These 40 min were separated into four stages of 10 min each: stage 1 - exercise intensity in which the HR remained at 50% of the HR peak achieved in the maximum effort test; stage 2 - 60% of the HR peak; stage 3 - 70% of HR peak and step 4 - maintaining 70% of HR peak. Afterwards, (4) there was a 1 min of recovery at 3 km/h and (5) 10 min of the same initial stretching and diaphragmatic breathing. HR and BP were obtained at the beginning of the session, at the end of each stage, recovery, and at the end of the session. The sessions were carried out individually and supervised by a physiotherapist.

The GI demonstrated a significant increase in all heart rate variability (HRV) indices, in the 6MWT distance, in cardiorespiratory fitness assessed by maximum oxygen consumption (VO2peak) during the exercise test, and a decrease in diastolic blood pressure after aerobic physical training. The study also evaluated other physiological parameters, such as body composition, blood pressure and metabolic profile, but found no significant differences between GI and GC.

The study had some limitations, namely reduced sample size and sample heterogeneity, which reduces the internal and external validity of the study.

Hassannejad et al., 2017[25] – The objective of this 3-arm controlled clinical trial was to compare the impact of two different unsupervised exercise programs on body composition and functional capacity results. For this, sixty morbidly obese patients (BMI≥35), 15 men and 45 women, aged 20–50 years, were evaluated before and after 12 weeks of gastric bypass and gastric band surgery. They were randomized into three groups: aerobic (A), strength + aerobic (AS) and control group (C). Body weight, percentage of body fat and fat mass reduced more in groups A and AS compared to group C. The researchers used a 12-minute walk test and sit-to-stand test to analyze functional capacity.

Two intervention groups (A and AS) were conducted to walk during the first 4 weeks after surgery and gradually increase speed to the tolerated threshold. Subjects were asked to walk 150 minutes per week. From week 5 to 12, total walking time increased to 150–200 min/week, 3–5 days/week in both groups at moderate intensity. Exercise intensity was suggested as 12 to 14 according to the Borg Scale. All subjects in the AS group were instructed to do three strength exercise sessions of 20 to 30 minutes, as well as walking from week 5 to 12. The green elastic band was given to female subjects and the blue one to male subjects, both of which did shoulder and hip strengthening exercises with the elastic bands, including extension, flexion, abduction and adduction. A booklet containing training photos with a complete description was given to the AS group. No exercise was prescribed for the C group.

In the AS group, the reduction in fat-free mass was significantly lower than in the other groups. The authors reported that functional capacity was improved in the 3 groups, assessed through mean changes in the 12-minute walk test. The mean change in sitting and standing scores was not statistically significant among the three groups.

This study had some limitations. First, the short duration of the trial and the lack of supervision of the exercise program. Longer follow-up may be needed to show more differences in changes in body composition between the two surgery methods. The other limitation was the heterogeneous nutritional characteristics due to the different procedures. Furthermore, the sample size was small, apart from the patients who dropped out of the study, which is indicated by the wide confidence intervals. A maximum effort test was not performed to prescribe endurance exercise intensity. All these factors reduce the internal and external validity of the study.

Herring LY et al., 2017[44] – this two-arm randomized clinical trial evaluated the effects of a 12-week supervised exercise intervention on physical function and body composition in obese women between 12 and 24 months after bariatric surgery. Assessments were carried out pre-intervention, post-intervention, at 12 and 24 weeks. Twenty-four sedentary patients, mostly women, were randomized to the exercise GI (n = 12) or GC (n = 12).

The exercise protocol consisted of three 60-minute gym sessions per week of moderate-intensity aerobic and resistance training for 12 weeks. Sessions took place in hospitals and supervised by a qualified fitness instructor with appropriate immediate life support training. All sessions consisted of a warm-up period, moderate-intensity aerobic training, and resistance training, ending with a cool-down period. The aerobic physical training element typically lasted 45 minutes; The first exercise program for participants consisted of 35 minutes with a longer warm-up period and progressed to 45 minutes at the end of week 2. Warm-ups were longer at the beginning of the 12 weeks and reduced to 5 min as conditioning progressed. The physique of individuals improved. The exercise session was personalized for each individual and reassessed every 2 weeks within the 12-week program. For the few participants who did not progress to 45 min in the first 2 weeks, they were reassessed weekly to achieve this duration. Moderate-intensity endurance exercise was expressed as a percentage of maximum heart rate; in the main exercise session this equates to between 64 and 77% (perceived exertion rating 12–14). Typically, the resistance training element consisted of four core and lower body endurance exercises (e.g., leg presses, abdominal twists, leg extensions) per week. Moderate intensity for endurance exercise was expressed as 60% of participants estimated one-repetition maximum. In the first session, a maximum of one repetition was identified, which was equated to performing a weight with which 17 repetitions were possible. Two endurance exercises were performed per participant per gym session; These varied, but only included core and lower body exercises. Participants would perform three sets of 12 repetitions with 30–60 s rest between sets. The entire exercise session totaled 60 minutes per participant.

Significant improvements in the exercise group were observed for incremental walking test (ISWT), body composition, physical function, cardiovascular and self-efficacy measures from baseline to 12 weeks. At 24 weeks, the exercise group recorded an improvement, and the control group recorded a reduction. Results show a 5.6 kg difference between groups in body mass change from baseline to 24 weeks, favoring the exercise group.

This study had some limitations. There were differences in baseline characteristics between the groups, which may have influenced the results. The sample was small and not heterogeneous. A maximum effort test was not performed to prescribe endurance exercise intensity. All these factors reduce the internal and external validity of the study.

3.4 BIAS RISK ANALYSIS AND METHODOLOGICAL ANALYSIS

The risk of bias analyzed in the studies was considered high, as shown in Figure 3. The main aspects identified were methodological problems, lack of information, multiple outcome measures, multiple eligible data analyses, and missing data.

The study carried out by Baillot A et al., 2018[41] was classified as "high risk of bias" by the "RoB 2.0" tool due to the lack of information regarding questions in domains 4 (measurement of outcomes) and 5 (reporting of outcomes).

Castello-Simões V et al., 2013[9], had their study classified as "high risk of bias" due to domain 4 (measurement of outcomes) being categorized as having "some concerns" due to the lack of information about the blinding of evaluators, and the domain 5 (outcome reporting) categorized as "high risk of bias" because it presented multiple outcome measures and multiple eligible data analyses.

The studies carried out by Castello V et al., 2011[21], Shah M et al., 2011[20] and Hassannejad A et al., 2017[25], were classified as "high risk of bias" because they presented multiple outcome measures and multiple eligible analyses of data in domain 5 (outcome reporting).

The study by Herring LY et al., 201736, due to the lack of information regarding domains 2 (deviations from the intended intervention), categorized as having "some concerns", and 4 (measurement of outcomes), categorized as "high risk of bias", led the study to also be classified overall as "high risk of bias. The risk of bias for each study is detailed in Figure 3.

Global assessment of risk of bias using the RoB 2.0 tool (Figure 3)

3.5 ANALYSIS OF CERTAINTY OF EVIDENCE AND STRENGTH OF RECOMMENDATION

Confidence in the results of this review was considered low, with the strength of recommendation being considered weak in favor of endurance exercise for the recovery of functional capacity in obese people after bariatric surgery. Possibly, the desirable effects outweigh the undesirable effects (weak recommendation in favor of the intervention). Therefore, confidence in the estimated effect is limited, and future studies are likely to significantly impact the estimated effect and probably modify it.

The main reason for the low confidence in the results was the low methodological quality of the included studies. The risk of bias was high in all included studies due to inadequate blinding of participants, loss of participants during the study, low sample size, and missing data. There were inconsistencies due to clinical, methodological, or statistical diversity among the included studies. There was inaccuracy in the results, mainly due to the small sample size and wide confidence interval. Problems with publication bias were also considered based on the strength of the findings; for example, studies that do not show a positive effect of an intervention are less likely to be published.

Furthermore, the studies analyzed did not present confounding factors, nor were strategies to deal with them established. Therefore, the risk of bias was considered severe, increasing the uncertainty of the review results.

4 DISCUSSION

This narrative systematic review provided an updated overview of physical exercise for post-bariatric surgery rehabilitation.

Bariatric surgery is an effective treatment option to achieve substantial weight loss and improve metabolic health in severely obese people[4,7,11,43]. However, even after surgery, individuals may experience a decline in functional capacity due to decreased physical activity and muscle strength[8]. To solve this problem, physical exercise programs have been implemented as part of postoperative care. However, the prescription of exercises for therapeutic purposes must have a scientific basis and be adapted to the patient's primary conditions and the desired objectives, following the principles of frequency, intensity, type, and time (FITT principle)[12]. Furthermore, the evidence supports the idea that exercise prescription for obese people after bariatric surgery should consider multiple factors, such as individual functional capacity, type of surgical procedure, weight loss patterns, and existing comorbidities[29]. Exercise programs must institute changes that combine a significant negative energy demand with long-term adherence to promote effective weight loss and health and well-being benefits, such as those obtained by improving functional capacity[38]. Therefore, adapting exercise programs for obese people, following all these requirements, is crucial to achieve ideal results.

Increased body weight puts excessive pressure on the musculoskeletal system, reducing mobility and increasing fatigue during physical exertion[3]. This phenomenon is due to several factors, including the need for a greater energy demand to move a heavier body mass[13,37]. Furthermore, chronic low-grade inflammation associated with obesity negatively impacts the cardiovascular, respiratory, and metabolic systems[11]. Consequently, individuals with obesity often experience substantial limitations in functional capacity[5,28].

Functional capacity refers to an individual's ability to perform daily activities, tasks, and movements efficiently and effectively[1]. It covers the physiological, psychological, and social dimensions necessary to perform these functions[15]. Functional capacity focuses on things people can do, fundamental activities of daily living, and performing socially expected roles.

Functional capacity is related to the concept of human functionality, proposed by the WHO, which adopts a biopsychosocial approach, reflecting the interaction between the various dimensions of health (biological, individual, and social), described in the components: body structure and function, activity, and participation[5]. However, this concept is often confused with physical fitness.

Functional capacity and physical fitness are interconnected concepts that contribute to global human performance, health, and quality of life, but they present significant conceptual similarities and differences[15]. Unlike functional capacity, physical fitness refers to physiological attributes related to the ability to perform a physical activity and exercise, often focused on specific tasks or sports[19,38]. However, laboratory tests, field measurements, and self-administered questionnaires can assess both. The standard parameters evaluated are cardiovascular resistance, muscular strength and endurance, flexibility, body composition, and balance[19]. However, the assessment of functional capacity has the main objective of evaluating the individual's ability to perform activities of daily living, such as walking, lifting, and climbing stairs, considering factors such as age, sex, and specific health conditions, being more linked to autonomy and independence[15]. On the other hand, physical fitness assessment focuses more on assessing an individual's capabilities in sports or exercise-related activities, often targeting specific performance goals[19,38].

The six articles we selected for this systematic review[9,20,21,25,41,44] reinforced the premise that physical training offers numerous benefits for patients after bariatric surgery, including increased lean body mass, improved quality of life, improved weight maintenance, and increased functional capacity. Our synthesis and analysis demonstrated, with a low confidence level, that both endurance exercise alone and endurance exercise combined with strength exercise demonstrated positive effects on the functional capacity of obese individuals after bariatric surgery.

Endurance exercise allows individuals to perform more daily activities at a lower relative intensity, being the most successful type of exercise for therapeutic purposes and the least time-consuming to improve aerobic capacity[38]. However, the increase in muscle strength resulting from resistance training can improve mobility and balance, as well as improve the ability to perform daily living activities. Combining endurance and strength exercise possibly improves general strength and body composition, leading to greater functional capacity. Corroborating this premise, current literature supports implementing a multimodal exercise program that combines endurance and strength exercise for optimal recovery of functional capacity in obese individuals after bariatric surgery.

Evidence suggests that a minimum of 150 minutes of moderate-intensity endurance exercise per week would be beneficial for weight maintenance and metabolic health in post-bariatric surgery patients[19,27,38]. However, if the current thinking that “exercise is medicine” is adopted, underdosing and overdosing are possible. Therefore, exercise may have a typical dose-response curve with a plateau in benefits or even adverse effects at more extreme levels in individuals with known or hidden diseases. Therefore, the prescribed exercise intensity must be above a minimum level necessary to induce a “training effect” but below the metabolic load that evokes significant symptoms.

For deconditioned/inactive individuals, the minimum intensity or threshold for improving cardiorespiratory fitness corresponds to ~60%-70% of the highest heart rate (HR) achieved during peak or symptom-limited exercise tests. However, considerable evidence suggests that the threshold increases in direct proportion to the initial level of fitness or level of habitual physical activity[38]. Therefore, we recommend that a peak or symptom-limited exercise test be performed for the most accurate endurance exercise prescription. For those previously sedentary patients beginning a physical conditioning program, and who have not undergone exercise stress testing, we recommend standing resting HR plus ~10 to 20 bpm for initial exercise intensity, using symptomatology and perceived exertion based on the scale. Borg score (from 11 [quite mild] to 13 [somewhat hard]) as adjuvant intensity modulators). Over time, exercise intensity should be gradually increased to 50-80% of exercise capacity, which approximates 70% to 85% of the highest HR achieved during peak or symptom-limited exercise testing. Additional methodologies and modulators of exercise intensity can be used, such as target HR, the concept of $\dot{V}O_{2R}$, and the metabolic equivalent rate (MET) method of activity prescription.

Therefore, with the weak recommendation, we recommend that endurance exercise of moderate to high intensity, 40-59% VO_{2max}, 55-69% HRmax, 40-59% FCR, 11-14 on the Borg perceived exertion scale, be included in the exercise program for obese individuals after bariatric surgery to recover functional capacity. As a recommendation of this review, exercises should preferably be supervised and can be performed on a treadmill, cycle ergometers, and free walking, among others.

Current evidence demonstrates that vigorous exercise appears to be more effective than moderate-intensity exercise in increasing functional capacity and other health outcomes, such as reducing insulin resistance and weight loss[38]. However, the risk of this intensity of exercise is not yet well understood, especially for the obese population.

We recommend that the session includes a 5–10-minute warm-up, 30–60-minute endurance exercise, and a 5–10-minute cool-down. According to evidence, warm-up exercises facilitate the transition from rest to training, reducing the risk of acute exercise-related events, and should include calisthenic exercises followed by activities that increase HR to within 20 bpm of the minimum HR target range prescribed for resistance training. Cooling down involves slow walking or low-intensity exercise, and provides a gradual recovery from the endurance or conditioning phase. It allows appropriate circulatory adjustments and return of the rate-pressure product to values close to rest; improves venous return, thereby reducing the potential for post-exercise hypotension and dizziness; facilitates the dissipation of body heat; promotes faster lactic acid removal than steady-state recovery and combats the potential deleterious effects of post-exercise increases in plasma catecholamines. Failure to cool down in the immediate post-exercise period may result in a transient decrease in venous return, possibly reducing coronary blood flow when HR and systolic blood pressure remain elevated. Consequences may include angina pectoris, ST segment ischemic depression, malignant ventricular arrhythmias, or combinations of these.

All studies analyzed in this review used continuous endurance exercises. However, it would be crucial to analyze the effects of high-intensity intermittent exercise, as recent studies have indicated that this type of exercise can cause superior fat loss and improve insulin sensitivity, in addition to more significant benefits in functional capacity. Because strength training is comparable to or superior to endurance training in increasing bone mineral density, muscle mass and strength, insulin sensitivity, and basal metabolism, it should be recommended to complement any fitness program. Therefore, the inclusion of strength exercise (moderate to intense, 70-80% 1RM) can likely enhance functional capacity results. However, we do not have sufficient evidence for this statement or to consider only strength exercise to recover functional capacity in the exercise program for obese people after bariatric surgery. Confidence in this result is limited, and future studies will likely impact it significantly and could probably modify it.

The studies included in this review mostly carried out 12 weeks of training. This period agrees with current scientific literature, which is the minimum period to observe an improvement in the functional capacity of obese people after bariatric surgery. Therefore, a minimum duration of 12 weeks, along with consistent adherence to diet, exercise, and increased levels of physical activity routines, should be recommended for physical rehabilitation programs targeting obese patients[27,38]. However, most investigations were conducted over short periods, with no long-term studies evaluating the sustained effects of exercise on the studied outcomes and quality of life in this population. Thus, the scientific community needs to address these gaps in evidence by conducting comprehensive, long-term studies that rigorously examine the optimal exercise prescription for individuals undergoing bariatric surgery. Such investigations would significantly improve our understanding of the role of exercise in optimizing outcomes and favor the development of personalized exercise programs for this population.

The duration and number of weekly sessions varied between studies, between 3 and 5 sessions per week. In clinical practice, it is understandable that individual variations may require adjustments to this prescribed duration. Based on the synthesis and recommendations made in this study, we recommend a minimum of 3 and a maximum of 5 weekly sessions of supervised endurance exercise for obese people after bariatric surgery. However, to compare scientific evidence, we consider that we do not have evidence of a smaller or more significant number of weekly sessions aimed at this outcome.

There are some additional challenges and future directions outlined in this review. There is limited research on long-term adherence and outcomes of exercise interventions in this population—furthermore, the heterogeneity of surgical procedures and individual responses to exercise highlight the need for personalized approaches. Future research should focus on the long-term effects of exercise interventions on functional capacity and explore potential factors influencing exercise adherence in this population.

5 CONCLUSION

Based on the findings of the included studies, we conclude that endurance exercise is the most recommended for recovering functional capacity in obese individuals after bariatric surgery. The addition of strength exercises can be useful in increasing strength and preventing the loss of lean mass, especially in the post-surgical period. Therefore, with weak recommendations and a low level of evidence, we recommend that endurance exercise be included in this program. Exercise prescription is an integral component of obesity management after bariatric surgery. Tailoring exercise programs based on individual ability and specific considerations is critical to long-term success. However, more research is needed to optimize and refine exercise guidelines in this population.

Supplemental Digital Content (SDC)

1. Spreadsheet with excluded studies and respective reasons

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