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Physical activity in patients after bariatric surgery - a literature review

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ABSTRACT

Introduction: Obesity is a growing global health concern, leading to severe comorbidities such as cardiovascular disease, diabetes, and depression. Bariatric surgery is an effective treatment for severe obesity, providing significant weight loss and health improvements. However, physical activity (PA) plays a critical role in enhancing these outcomes, including sustained weight loss, improved fitness, and better mental health.

Materials and methods: The authors searched PubMed, UpToDate, Google Scholar, Cochrane Library, and Science Direct to review the available medical literature about physical activity after bariatric surgery. The following keywords: *sport, physical activity, obesity, bariatric surgery* were used to search for papers.

Results: This review examines the benefits of PA after bariatric surgery, highlighting its impact on reducing weight regain, maintaining lean body mass, and improving quality of life. It also explores the unique challenges associated with primary obesity and post-bariatric surgery, such as joint pain, loose skin, nutritional deficiencies, and psychological barriers, which often prevent patients from engaging in PA.

Conclusions: The review emphasizes the need for clear guidelines, tailored interventions, and multidisciplinary support to address these challenges. By promoting PA and providing comprehensive care, healthcare providers can ensure long-term success and improved quality of life for bariatric patients.

Keywords: *sport, physical activity, obesity, bariatric surgery*

INTRODUCTION

Obesity is a severe and widespread health problem. Over the past half-century, the prevalence of obesity has increased to pandemic levels. It is estimated that almost one-third of the world's population is overweight or obese (1). The pathogenesis of obesity is a component of various factors - environmental, genetic, behavioral, social (2).

According to the WHO definition, obesity is classified as excessive accumulation of fatty tissue that may negatively impact on health. The BMI index is used to assess the severity of overweight/obesity, calculated as the quotient of body weight in kilograms and the square of height in meters. Normal BMI values range from 18.5 - 24.9 kg/m^2, BMI >=25 kg/m^2 indicates overweight, and obesity is defined as BMI >=30 kg/m^2 (3). Moreover, obesity is a significant risk factor for cardiovascular diseases (heart attack, stroke, hypertension), metabolic diseases (type 2 diabetes, fatty liver disease), some types of cancer (including colon, kidney, breast), osteoarthritis, and depression. That is why it is so important to diagnose and start appropriate

treatment as soon as possible (4, 5). The basis of obesity treatment is lifestyle modification. In addition, drugs with different mechanisms of action and surgical methods are also used.

According to the criteria established by the National Institutes of Health, candidates for bariatric surgery are patients with a BMI>40 kg/m^2, patients with a BMI of 35-40 kg/m^2 with comorbidities, but also patients with a BMI of 30-35 kg/m^2 with type 2 diabetes that cannot be controlled despite treatment, or with metabolic syndrome (6, 7).
The most important types of bariatric surgery include: sleeve gastrectomy (SG) (which is the most commonly performed surgery), adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB) and bilio-pancreatic diversion (BPD) (8). Data from randomized clinical trials have shown that the effects of bariatric surgery (weight loss and initial remission of type 2 diabetes) are better than lifestyle changes and medical interventions. The results of several observational studies have shown a reduction in cardiovascular risk, improved long-term survival and comorbidities in patients who underwent surgery compared to patients who did not (9). However, the role of physical activity post-surgery is often overlooked, despite its potential to enhance surgical outcomes.
This paper aimed to review the literature on physical activity, factors that may influence sports participation, and the benefits of PA in patients after bariatric surgery.

MATERIALS AND METHODS

The authors searched PubMed, UpToDate, Google Scholar, Cochrane Library, and Science Direct to review the available medical literature about physical activity after bariatric surgery. The following keywords: *sport, physical activity, obesity, bariatric surgery* were used to search for papers. The scientific papers considered were published between 2000 and 2024. After reviewing the abstracts, 52 scientific papers on the topic were selected and thoroughly analyzed. The results are presented in this article.

BENEFITS OF PHYSICAL ACTIVITY

The available literature has repeatedly shown sport's positive impact on a person's mental and physical health. Physically active people are certainly less likely to suffer from stroke, type 2 diabetes, some types of cancer, osteoporosis, sarcopenia, and also maintain active longer in old age (10).
In the overweight and obese population, team sports have been shown to have a beneficial effect on metabolic health and physical efficiency. Decreases in BMI and body fat percentage have been observed. In addition, significant benefits have been demonstrated in cardiovascular health - reductions in systolic blood pressure. However, no effect on diastolic blood pressure has been confirmed. Most studies have shown reductions in total cholesterol and triglyceride levels. Overall, aerobic fitness consistently improves with team sports (11). Participation in sports and physical exercise are also considered beneficial for mental health, improving mood and quality of life, and reducing stress levels (12). M. Maggisano et al. conducted a questionnaire study in which they showed that patients with increased levels of physical activity (PA) had reduced depressive symptoms and improved quality of life compared to patients whose PA remained

unchanged or decreased (13). Sport and physical activity significantly influence metabolism, affecting how the human body produces, uses, and stores energy. Lack of physical activity is a basic mechanism for the development of dyslipidemia, hypertension, hyperglycemia - components of the metabolic syndrome.

Physical activity plays a great role in improving outcomes following bariatric surgery. Numerous studies have shown that regular physical activity supports sustained weight loss, enhances body composition, improves cardiorespiratory fitness, and reduces the risk of recurrence of comorbid conditions, such as type 2 diabetes and cardiovascular diseases (14-16). Physical activity also contributes to better quality of life and provides protective effects against mental health disorders like depression and anxiety (17).

Patients who increase their physical activity levels after surgery experience additional fat loss and improved physical fitness compared to those who remain less active (14). Research also highlights the benefits of strength training, which helps preserve lean body mass and reduces bone density loss (14).

Bariatric patients face many complications of obesity, such as musculoskeletal pain or chronic diseases, which can significantly affect physical performance, as well as the desire to play sports. Scientific studies have repeatedly indicated the importance of physical activity, undertaken both before and after bariatric surgery. The huge role of continuing physical activity is emphasized, because it results in improved aerobic capacity, reduced cardiovascular risk, and maintenance of lean body mass.

There are currently no particular guidelines for physical activity recommendations before or after bariatric surgery. Based on the general recommendations by Mastaneh Rajabian Tabesh et al., the following activity schedule is recommended:

- at least 150 min/week of moderate to vigorous physical activity (equivalent to 3–6 METs) or
- 10,000 steps/day to improve overall health

and

-150–250 min/week to prevent weight regain,

and

- more than 300 min/week to maintain weight after weight loss (18).

Unfortunately, the majority of patients after bariatric surgery fail to meet recommended levels of physical activity, limiting the potential health benefits (14). It is crucial that each patient is treated individually, to match the appropriate type of exercise to the patient's mobility, condition, and comorbidities.

BARRIERS TO PHISICAL ACTIVITY

Despite the well-documented benefits of physical activity (PA) for patients following bariatric surgery, numerous barriers often prevent individuals from adopting and maintaining active lifestyles. Excessive weight before surgery often leads to joint-related conditions, such as osteoarthritis, which may persist post-surgery and the the coexistin pain may lead to limited physical mobility. Chronic pain or discomfort during exercise can make even moderate-intensity activities challenging (17, 19).Physical side effects after bariatric surgery, including fatigue, nausea, or nutritional deficiencies, may lower the ability to engage in PA. These

symptoms can reduce stamina and motivation, making it harder to establish a consistent routine (19). Even after substantial weight loss, many patients report ongoing dissatisfaction with their bodies. The visibility of excess skin or residual weight can cause negative feelings, preventing participation in physical activities. One of the most challenging barriers is the discomfort caused by loose skin after significant weight loss.

Skin folds can lead to irritation, discomfort during movement, and embarrassment, deterring individuals from engaging in physical activities, especially in public or group settings (17). Patients often struggle with a lack of confidence in their ability to perform physical activities effectively. Fear of injury or failure can discourage attempts to increase activity levels (20).

Sustaining motivation for PA can be difficult, particularly when the immediate rewards (e.g., weight loss) get smaller over time. Without strong motivators or external encouragement, many patients revert to sedentary behaviors (21).

Addressing the barriers to physical activity after bariatric surgery requires a comprehensive approach that considers the challenges faced by each patient. Personalized, multi-faceted interventions should target physical limitations, enhance psychological well-being, and promote social support. Recognizing and addressing these could ultimately optimize the long-term outcomes of bariatric surgery

NUTRITIONAL DEFICIENCES

Bariatric surgery is often associated with impaired absorption of key macro- and micronutrients, such as iron, calcium, zinc, and vitamins, especially those that involve extensive intestinal bypass, such as biliopancreatic diversion and omega gastric bypass (8). Paradoxically, obesity itself may be associated with malnutrition. Hypotheses are mainly based on an unbalanced and ultra - processed diet with a predominance of carbohydrates and saturated fats. Researchers postulate that obesity, as an inflammatory disease, impairs the absorption of important nutrients (22).

Iron deficiency after bariatric surgery results from reduced intake of the element, reduced secretion of hydrochloric acid (which causes difficult reduction of trivalent iron to the absorbable form of divalent iron), and a reduced absorption surface. It is estimated that this problem affects 18-53% of patients after Roux-en-Y gastric bypass and 1-54% of patients after sleeve gastrectomy (23-25).

The pathophysiology of vitamin B12 deficiency after bariatric surgery is complex. In patients after RYBG, there is reduced acid and pepsin digestion of cobalamins combined with protein supplied from food, incomplete release of vitamin B12 from proteins called "R proteins" due to impaired mixing of nutrients with pancreatic juices, and reduced availability of intrinsic factor (26). Vitamin B12 deficiency after RYGB ranges from 26% to 70%. In contrast, in patients undergoing procedures such as LAGB and LSG, cobalamin deficiency is less common (27).

Folic acid deficiency is much less common, because it is absorbed over a large surface area of the small intestine. Some researchers suggest that folic acid deficiency is a measure of non-compliance with recommended supplementation (28, 29).

All of the above factors can lead to micro-, macro- and normocytic anemia. Usually, iron deficiency is characterized by reduced blood cell size (MCV <80fL), while folic acid and vitamin B12 deficiency increased blood cell size (MCV>99fL) (30).

Due to limited oxygen supply to the muscles and impaired energy production, anemia contributes to faster muscle fatigue and worse exercise tolerance. Iron deficiency, even without developed anemia, can negatively affect physical performance by impairing mitochondrial function, limiting muscle's ability to store glycogen, and disrupting aerobic metabolism. These changes reduce energy and the body's efficiency during physical exercise.

S. Mohapatra et al. in their review, presented several key nutritional recommendations for patients after bariatric surgery.

The investigators emphasized adequate protein intake (60–80 g or 1.1 g/kg ideal body weight after LSG, and 90 g after BPDS, 60–120 g after RYGB) combined with regular resistance training and aerobic exercise to maintain lean tissue mass. In addition, supplements of iron, thiamine, and folic acid, calcium, and vitamin D (min. 3000 international units to ensure >30 ng/ml) should be given to all patients (31).

Hélène Vinolas et al. in their paper, probably for the first time, assessed the degree of oral hydration after bariatric surgery. They showed that oral hydration significantly decreases, especially after RYGB. It is not without significance that about 30-60% of patients experience nausea and vomiting for several months after the surgery. Dehydration, after nausea and vomiting (12.95%) and abdominal pain (11.75%), is the third cause (10.54%) of early hospitalizations after bariatric surgery (32, 33).

HYPOGLICEMIA AND ENERGY LEVELS

A rare complication of bariatric surgery is p*ost-bariatric hypoglycemia (PBH)*. It is characterized by the occurrence of hypoglycemia symptoms about 1-3 hours after a high-carbohydrate meal. It is postulated that hypoglycemia is a result of anatomical and physiological changes that occur after bariatric surgery. As a result, the consumed food quickly reaches the jejunum and ileum, causing faster glycemia peaks than patients who have not undergone bariatric surgery. It is believed that the pathogenesis involves increased values of gluconic peptide type 1 (GLP-1) and insulin, and at the same time reduced release of hormones with antagonistic effects (34, 35).

The spectrum of symptoms remains very wide - from asymptomatic patients to patients having many hypoglycemia episodes every day, which significantly affects the quality of life. For this reason, the incidence of PBH is very difficult to determine. Based on the conducted registries, it is estimated that PBH occurs in 0.1-0.9% of patients. However, data from, for example, continuous glucose monitoring indicated that hypoglycemia occurs in 25-75% of patients (36).

It is recommended to diagnose PBH in patients who have undergone bariatric surgery and have: biochemically confirmed hypoglycemia - glucose <54mg/dL or<3.00mmol/l; symptoms of hypoglycemia - tremors, anxiety, increased sweating, tachycardia, fainting, dizziness; symptoms disappear after blood glucose levels are balanced (37).

Repeated episodes of hypoglycemia and related symptoms making difficult to sustain prolonged or intense activity.

FRACTURE RISK

Despite the many health benefits, over the years, the negative impact of bariatric surgery on the musculoskeletal system has been noticed. Compared to various non-surgical control groups (obese, non-obese, general population), the risk of fractures, especially in the upper limb, increases significantly after bariatric surgery. Interestingly, it has been proven that this risk depends on the type of bariatric surgery - the highest occurs after RYBG (38).

The impact of bariatric surgery on the musculoskeletal system remains multifactorial. It has been proven that the fracture pattern changes as a result of bariatric surgery - from the typical obesity pattern to the osteoporotic one (39).

The potential mechanisms show a wide spectrum of action, but it should be emphasized that vitamin D deficiency, insufficient intake and poor calcium absorption play an important role. After RYBG surgery, suboptimal calcium absorption occurs. As a result, parathyroid hormone (PTH) secretion increases, which causes increased bone resorption in order to maintain normocalcaemia. However, bone resorption also increases due to PTH-independent processes, such as changes in the hormonal environment. The above mechanisms lead, among others, to a decrease in bone mineral density (BMD).

The positive impact of sports on bone health is widely known - physical activity in the 2nd-3rd decade of life (when peak bone mass occurs) leads to beneficial adaptive changes that improve bone architecture by improving geometric properties and increasing bone density (40). In the population of patients after bariatric surgery, studies suggest that exercise is one of the therapeutic options for treating bone loss caused by weight loss surgery. F. Diniz-Sousa et al. in their RCT, they proved that an 11-month exercise intervention caused an increase in BMD of the lumbar spine and 1/3 of the radius (41).

On the other hand, we cannot ignore the fact that increased physical activity also leads to an increased risk of falls and injuries, and it causes an increased risk of traumatic fractures. Given the circumstances, there is a clear need for long-term bone monitoring in this group of patients (42).

WEIGHT REGAIN

Although bariatric surgery is the most effective form of obesity treatment, some patients will experience weight gain and thus a recurrence of diseases coexisting with obesity (43). Moreover, it also has a great impact on the psyche of the patient, who, despite enormous efforts, such as the decision to undergo surgery, fails to maintain weight. This can even lead to depressive disorders (44).

Caloric restriction alone does not permanently maintain weight. Reported data suggest that approximately 30–50% of the initial weight loss is regained after approximately 1–1.5 years. However, exercise is beneficial for long-term weight loss maintenance after caloric restriction. The National Weight Control Registry (NWCR) from the USA suggests that moderate-intensity exercise is essential for maintaining weight loss (45). Lifestyle modification is the basis for the prevention and treatment of weight regain after surgery (46). Patients struggling with obesity must face many challenges including their own limitations, psychological attitude, social

support, and confronting expectations with individual capabilities. Researchers suggest that postoperative success is mainly focused on reducing the occurrence of stress factors and behavioral change.

E.C. Romagna et al. conducted a study assessing the relationship between lifestyle and the rate of weight regain. They showed that a sedentary lifestyle and low physical activity are associated with a higher rate of weight regain. The researchers also emphasized the key role of postoperative care and monitoring of patients - according to them, bariatric patients who are not under the care of a specialist do not follow the recommendations optimally and do not exercise enough (47).

A study examining the relationship between physical activity and the risk of weight regain after bariatric surgery was created by C. Santos et al. They also confirmed the thesis that appropriate physical activity correlates with a lower risk of weight regain.

In addition, they showed that practicing sports is associated with improved sleep quality and an improvement in the quality of life in general (48).

J. Odom et al. conducted a study demonstrating the risk factors of regaining weight after RYBG surgery, related to the patients' behavior. These include decreased well-being, a strong need to eat, limited follow-up visits and lack of self-control (49). Other researchers also add a sedentary lifestyle to this list.

The above data undoubtedly emphasize the importance of physical activity in ensuring the maintenance of body weight after bariatric surgery.

PREOPERATIVE INTERVENTION

Building healthy habits is the foundation for improving the quality of life and allows for maintaining well-being for many years. Physical activity should be promoted from the earliest years by creating pro-health behaviors in children. Unfortunately, many studies have shown that, objectively, most patients have low physical activity before surgery and make modest changes in PA after surgery.

D.S. Bond et al. designed and conducted a randomized control trial (*BARI-ACTIVE)* and concluded that a 6-week behavioral intervention, consisting of encouraging exercise at home before surgery (using individual therapies), led to an increase in physical activity. Based on this study, they conducted another study, which showed that the behavioral intervention increased intrinsic motivation to practice sports, facilitated overcoming barriers, and also increased the enjoyment of physical activity. (50, 51).

Of course, changing behaviors that have been practiced for years is a very demanding process. Barriers to physical activity concern aspects - both in the private, social and environmental sphere. Some of them may even prevent patients from adopting and maintaining a physically active lifestyle. On the other hand, there are also factors that will motivate bariatric patients to practice sports. Many factors were assessed that could influence the change in the perception of physical activity by bariatric patients. Interestingly, a change in the fitness organization, a noticeable weight loss, and the role of support from friends had a statistically significant effect on the change in physical activity in the pre- and postoperative period (52).

CONCLUSION

Physical activity plays a vital role in improving the outcomes of bariatric surgery. It helps maintain weight loss, enhances physical fitness, and lowers the risk of comorbidities like type 2 diabetes and heart disease. Additionally, it improves mental well-being, quality of life, and reduces the risk of depression and anxiety.

Despite these benefits, many patients struggle to remain active after surgery due to challenges such as physical discomfort, loose skin, lack of motivation, and limited support. Addressing these challenges requires individualized care and practical solutions.

Key recommendations include:

- Developing clear guidelines for the type and intensity of physical activity appropriate after surgery.
- Providing nutritional advice to prevent deficiencies that can affect recovery and energy levels.
- Making physical activity an essential part of postoperative care to support long-term success.
- Using a team-based approach with input from healthcare professionals, such as dietitians, physiotherapists, and psychologists, to provide full support to patients.

More research is needed to create effective physical activity plans for bariatric patients, explore ways to maintain activity levels over time, and understand how pre- and postoperative programs can support better outcomes.

By focusing on these areas, healthcare providers can help patients achieve long-lasting benefits from bariatric surgery, improving both physical health and overall quality of life.

DISCLOSURE

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REFERENCES

1. Bluher M. Obesity: global epidemiology and pathogenesis. Nat Rev Endocrinol. 2019;15(5):288-98.
2. Via M. The malnutrition of obesity: micronutrient deficiencies that promote diabetes. ISRN Endocrinol. 2012;2012:103472.
3. Prospective Studies C, Whitlock G, Lewington S, Sherliker P, Clarke R, Emberson J, et al. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet. 2009;373(9669):1083-96.
4. Chooi YC, Ding C, Magkos F. The epidemiology of obesity. Metabolism. 2019;92:6-10.
5. Engin A. The Definition and Prevalence of Obesity and Metabolic Syndrome: Correlative Clinical Evaluation Based on Phenotypes. Adv Exp Med Biol. 2024;1460:1-25.
6. Wolfe BM, Kvach E, Eckel RH. Treatment of Obesity: Weight Loss and Bariatric Surgery. Circ Res. 2016;118(11):1844-55.
7. Hsu WC, Araneta MR, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. Diabetes Care. 2015;38(1):150-8.
8. Topart P. Obesity surgery: Which procedure should we choose and why? J Visc Surg. 2023;160(2S):S30-S7.
9. Arterburn DE, Courcoulas AP. Bariatric surgery for obesity and metabolic conditions in adults. BMJ. 2014;349:g3961.
10. Blair SN, Morris JN. Healthy hearts--and the universal benefits of being physically active: physical activity and health. Ann Epidemiol. 2009;19(4):253-6.

11. Wang T, Yang L, Xu Q, Dou J, Clemente FM. Effects of recreational team sports on the metabolic health, body composition and physical fitness parameters of overweight and obese populations: A systematic review. Biol Sport. 2024;41(3):243-66.
12. Szmodis M, Zsakai A, Blasko G, Feher P, Annar D, Sziraki Z, et al. Effects of regular sport activities on stress level in sporting and non-sporting university students. Physiol Int. 2022;109(2):293-304.
13. Maggisano M, Maeda A, Okrainec A, Wnuk S, Sockalingam S, Jackson T. Physical activity and its association with psychosocial health following bariatric surgery. Appl Physiol Nutr Metab. 2019;44(12):1379-82.
14. Bellicha A, van Baak MA, Battista F, Beaulieu K, Blundell JE, Busetto L, et al. Effect of exercise training before and after bariatric surgery: A systematic review and meta-analysis. Obes Rev. 2021;22 Suppl 4(Suppl 4):e13296.
15. Zabatiero J, Smith A, Hill K, Hamdorf JM, Taylor SF, Hagger MS, et al. Do factors related to participation in physical activity change following restrictive bariatric surgery? A qualitative study. Obes Res Clin Pract. 2018;12(3):307-16.
16. Tettero OM, Aronson T, Wolf RJ, Nuijten MAH, Hopman MTE, Janssen IMC. Increase in Physical Activity After Bariatric Surgery Demonstrates Improvement in Weight Loss and Cardiorespiratory Fitness. Obes Surg. 2018;28(12):3950-7.
17. Beltran-Carrillo VJ, Jimenez-Loaisa A, Jennings G, Gonzalez-Cutre D, Navarro-Espejo N, Cervello E. Exploring the socio-ecological factors behind the (in)active lifestyles of Spanish post-bariatric surgery patients. Int J Qual Stud Health Well-being. 2019;14(1):1626180.
18. Tabesh MR, Maleklou F, Ejtehadi F, Alizadeh Z. Nutrition, Physical Activity, and Prescription of Supplements in Pre- and Post-bariatric Surgery Patients: a Practical Guideline. Obes Surg. 2019;29(10):3385-400.
19. Dikareva A, Harvey WJ, Cicchillitti MA, Bartlett SJ, Andersen RE. Exploring Perceptions of Barriers, Facilitators, and Motivators to Physical Activity Among Female Bariatric Patients: Implications for Physical Activity Programming. Am J Health Promot. 2016;30(7):536-44.
20. Wouters EJ, Larsen JK, Zijlstra H, van Ramshorst B, Geenen R. Physical activity after surgery for severe obesity: the role of exercise cognitions. Obes Surg. 2011;21(12):1894-9.
21. James JD, Hardeman W, Goodall M, Eborall H, Sprung VS, Bonnett LJ, et al. A systematic review of interventions to increase physical activity and reduce sedentary behaviour following bariatric surgery. Physiotherapy. 2022;115:1-17.
22. Kaidar-Person O, Person B, Szomstein S, Rosenthal RJ. Nutritional deficiencies in morbidly obese patients: a new form of malnutrition? Part A: vitamins. Obes Surg. 2008;18(7):870-6.
23. Steenackers N, Van der Schueren B, Mertens A, Lannoo M, Grauwet T, Augustijns P, et al. Iron deficiency after bariatric surgery: what is the real problem? Proc Nutr Soc. 2018;77(4):445-55.
24.Ishida RK, Faintuch J, Paula AM, Risttori CA, Silva SN, Gomes ES, et al. Microbial flora of the stomach after gastric bypass for morbid obesity. Obes Surg. 2007;17(6):752-8.
25. Broeke R, Bravenboer B, Smulders FJ. Iron deficiency before and after bariatric surgery: the need for iron supplementation. Neth J Med. 2013;71(8):412-7.

26. Kushner RF. Micronutrient deficiencies and bariatric surgery. Current Opinion in Endocrinology, Diabetes and Obesity. 2006;13(5):405-11.
27. Majumder S, Soriano J, Louie Cruz A, Dasanu CA. Vitamin B12 deficiency in patients undergoing bariatric surgery: preventive strategies and key recommendations. Surg Obes Relat Dis. 2013;9(6):1013-9.
28. Brolin RE, Gorman JH, Gorman RC, Petschenik AJ, Bradley LJ, Kenler HA, et al. Are vitamin B12 and folate deficiency clinically important after roux-en-Y gastric bypass? J Gastrointest Surg. 1998;2(5):436-42.
29. Krzizek EC, Brix JM, Stockl A, Parzer V, Ludvik B. Prevalence of Micronutrient Deficiency after Bariatric Surgery. Obes Facts. 2021;14(2):197-204.
30. Tefferi A. Anemia in adults: a contemporary approach to diagnosis. Mayo Clin Proc. 2003;78(10):1274-80.
31. Mohapatra S, Gangadharan K, Pitchumoni CS. Malnutrition in obesity before and after bariatric surgery. Dis Mon. 2020;66(2):100866.
32. Vinolas H, Barnetche T, Ferrandi G, Monsaingeon-Henry M, Pupier E, Collet D, et al. Oral Hydration, Food Intake, and Nutritional Status Before and After Bariatric Surgery. Obes Surg. 2019;29(9):2896-903.
33. Aman MW, Stem M, Schweitzer MA, Magnuson TH, Lidor AO. Early hospital readmission after bariatric surgery. Surg Endosc. 2016;30(6):2231-8.
34. Carpentieri GB, Goncalves S, Mourad WM, Pinto LGC, Zanella MT. Hypoglycemia post bariatric surgery: drugs with different mechanisms of action to treat a unique disorder. Arch Endocrinol Metab. 2023;67(3):442-9.
35. Capristo E, Panunzi S, De Gaetano A, Spuntarelli V, Bellantone R, Giustacchini P, et al. Incidence of Hypoglycemia After Gastric Bypass vs Sleeve Gastrectomy: A Randomized Trial. J Clin Endocrinol Metab. 2018;103(6):2136-46.
36. Goldfine AB, Patti ME. How common is hypoglycemia after gastric bypass? Obesity (Silver Spring). 2016;24(6):1210-1.
37. Hazlehurst J, Khoo B, Lobato CB, Ilesanmi I, Abbott S, Chan T, et al. Society for Endocrinology guidelines for the diagnosis and management of post-bariatric hypoglycaemia. Endocr Connect. 2024;13(5).
38. Zhang Q, Chen Y, Li J, Chen D, Cheng Z, Xu S, et al. A meta-analysis of the effects of bariatric surgery on fracture risk. Obes Rev. 2018;19(5):728-36.
39. Rousseau C, Jean S, Gamache P, Lebel S, Mac-Way F, Biertho L, et al. Change in fracture risk and fracture pattern after bariatric surgery: nested case-control study. BMJ. 2016;354:i3794.
40. Tenforde AS, Fredericson M. Influence of sports participation on bone health in the young athlete: a review of the literature. PM R. 2011;3(9):861-7.
41. Diniz-Sousa F, Veras L, Boppre G, Sa-Couto P, Devezas V, Santos-Sousa H, et al. The Effect of an Exercise Intervention Program on Bone Health After Bariatric Surgery: A Randomized Controlled Trial. J Bone Miner Res. 2021;36(3):489-99.

42. Ahlin S, Peltonen M, Sjoholm K, Anveden A, Jacobson P, Andersson-Assarsson JC, et al. Fracture risk after three bariatric surgery procedures in Swedish obese subjects: up to 26 years follow-up of a controlled intervention study. J Intern Med. 2020;287(5):546-57.
43. Magro DO, Ueno M, Coelho-Neto JS, Callejas-Neto F, Pareja JC, Cazzo E. Long-term weight loss outcomes after banded Roux-en-Y gastric bypass: a prospective 10-year follow-up study. Surg Obes Relat Dis. 2018;14(7):910-7.
44. Rutledge T, Groesz LM, Savu M. Psychiatric factors and weight loss patterns following gastric bypass surgery in a veteran population. Obes Surg. 2011;21(1):29-35.
45. Coen PM, Goodpaster BH. A role for exercise after bariatric surgery? Diabetes Obes Metab. 2016;18(1):16-23.
46. Velapati SR, Shah M, Kuchkuntla AR, Abu-Dayyeh B, Grothe K, Hurt RT, et al. Weight Regain After Bariatric Surgery: Prevalence, Etiology, and Treatment. Curr Nutr Rep. 2018;7(4):329-34.
47. Romagna EC, Lopes KG, Mattos DMF, Farinatti P, Kraemer-Aguiar LG. Physical Activity Level, Sedentary Time, and Weight Regain After Bariatric Surgery in Patients Without Regular Medical Follow-up: a Cross-Sectional Study. Obes Surg. 2021;31(4):1705-13.

48. Santos C, Carvalho M, Oliveira L, Palmeira A, Rodrigues LM, Gregorio J. The Long-Term Association between Physical Activity and Weight Regain, Metabolic Risk Factors, Quality of Life and Sleep after Bariatric Surgery. Int J Environ Res Public Health. 2022;19(14).
49. Odom J, Zalesin KC, Washington TL, Miller WW, Hakmeh B, Zaremba DL, et al. Behavioral predictors of weight regain after bariatric surgery. Obes Surg. 2010;20(3):349-56.
50. Bond DS, Graham Thomas J, Vithiananthan S, Webster J, Unick J, Ryder BA, et al. Changes in enjoyment, self-efficacy, and motivation during a randomized trial to promote habitual physical activity adoption in bariatric surgery patients. Surg Obes Relat Dis. 2016;12(5):1072-9.
51. Bond DS, Vithiananthan S, Thomas JG, Trautvetter J, Unick JL, Jakicic JM, et al. Bari-Active: a randomized controlled trial of a preoperative intervention to increase physical activity in bariatric surgery patients. Surg Obes Relat Dis. 2015;11(1):169-77.
52. Kovacs SJ, Courcoulas AP, Rogers RJ, Davis KK, Jakicic JM. Psychosocial factors associated with physical activity in patients who have undergone bariatric surgery. Surg ObesRelat Dis. 2020;16(12):1994-2005.