Long-Term Effectiveness of Low-Carbohydrate vs Balanced Diets in Obesity Treatment and Nutritional Interventions Post-Bariatric Surgery: A case Study

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***Abstract*:** The study titled Long-term effectiveness of low-carbohydrate vs balanced diets in obesity treatment, and nutritional interventions post-bariatric surgery: A case study examines the long-term impact of two dietary approaches—low-carbohydrate diets and balanced diets—on obesity management, as well as the role of nutritional interventions following bariatric surgery.

The research explores how different nutritional strategies influence weight loss, metabolic health, and long-term weight maintenance in individuals with obesity. It compares the effectiveness of:Low-carbohydrate diets, which focus on reducing carbohydrate intake to enhance fat metabolism and weight reduction.Balanced diets, which provide moderate proportions of carbohydrates, proteins, and fats while emphasizing overall nutritional adequacy.The study also investigates the nutritional challenges faced by patients after bariatric surgery, including vitamin and mineral deficiencies, dietary adaptation, and lifestyle changes required for sustained health outcomes. Using a case-study approach, the research highlights:The importance of individualized dietary planning.

The role of continuous nutritional monitoring after surgery.

The psychological and behavioral factors influencing adherence to dietary regimens.The effectiveness of combining medical, nutritional, and lifestyle interventions for long-term obesity treatment.

Keywords: Long-term - low-carbohydrate - balanced diets - obesity treatment - Nutritional Interventions -Post-bariatric surgery- A case study

Obesity has become one of the most critical global health challenges, with its prevalence rising dramatically over recent decades. It is a complex, multifactorial condition associated with increased risks of metabolic disorders, cardiovascular diseases, and premature mortality. As a result, identifying effective and sustainable treatment strategies remains a major priority in clinical and public health research.

Dietary interventions are considered the cornerstone of obesity management, with low-carbohydrate and balanced diets being among the most widely adopted approaches. Low-carbohydrate diets, characterized by reduced carbohydrate intake and increased consumption of fats and proteins, have been shown to produce rapid short-term weight loss and improvements in glycemic control. Meta-analyses of randomized controlled trials indicate that such diets can result in significantly greater weight reduction within the first 3–6 months compared to other dietary patterns(Giovanni ; Claudia ; Federica ; Francesco ; Federica ;Edoardo ; Barbara ,2022).

Similarly, large-scale systematic reviews have confirmed a dose–response relationship between carbohydrate restriction and short-term weight loss outcomes (Soltani;Jayedi; Abdollahi; Vasmehjani; Meshkini; Shab-Bidar,2023).

However, the long-term effectiveness of low-carbohydrate diets remains controversial. Evidence from high-quality randomized trials and systematic reviews suggests that differences in weight loss between low-carbohydrate and balanced diets tend to diminish over time, with minimal clinically significant differences observed after 12–24 months (Naude; Brand; Schoonees;Nguyen;Chaplin;Volmink ,2022) .

Furthermore, recent cohort studies highlight that the quality and source of macronutrients within low-carbohydrate diets play a critical role in long-term weight regulation. Diets emphasizing plant-based proteins and healthy fats are associated with better weight outcomes, whereas those rich in animal fats and refined carbohydrates may lead to weight gain over time (Liu ; Hu; Rai; Wang; Hu& Sun ,2023).

Additionally, prospective research published in The BMJ demonstrates that long-term weight changes are more strongly influenced by overall dietary patterns rather than carbohydrate restriction alone (Yi Wan; Deirdre ,Tobias; Kristine ; Dennis; Marta Guasch-Ferré, ; Qi Sun; Eric B Rimm; Frank B Hu; David S Ludwig; Orrin Devinsky; Walter ,C Willett,2023).

In contrast, balanced diets—characterized by appropriate proportions of carbohydrates, proteins, and fats—are generally associated with improved dietary quality, better adherence, and more sustainable long-term outcomes. These diets support overall health by providing essential nutrients and reducing the risk of micronutrient deficiencies, which have been reported in individuals following restrictive low-carbohydrate regimens.

For individuals with severe obesity, bariatric surgery has emerged as the most effective intervention, leading to substantial and sustained weight loss as well as improvement or remission of

obesity-related comorbidities. Nevertheless, the success of bariatric procedures is highly dependent on appropriate postoperative nutritional management. Due to anatomical and physiological changes following surgery, patients are at increased risk of deficiencies in essential nutrients such as vitamin B12, iron, calcium, and vitamin D. Therefore, structured dietary progression and lifelong supplementation are essential components of post-bariatric care.

Given these considerations, this study aims to evaluate the long-term effectiveness of low-carbohydrate versus balanced diets in the treatment of obesity, while also examining the role of nutritional interventions following bariatric surgery through a case study approach. By integrating current evidence with clinical application, this research seeks to provide a comprehensive understanding of sustainable obesity management strategies and optimize patient outcomes.

Definition of obesity and its importance as a global health problem:

Obesity is defined as a chronic and complex medical condition characterized by excessive or abnormal accumulation of body fat that may impair health. The World Health Organization (WHO) identifies obesity in adults using Body Mass Index (BMI), where a BMI of 30 kg/m² or higher is considered obese. Obesity results from interactions among genetic, behavioral, environmental, and metabolic factors, making it more than simply a consequence of overeating or physical inactivity. In recent years, obesity has increasingly been recognized as a multifactorial disease requiring long-term prevention and management strategies(World Heath Organization ,2025).

Obesity is defined as a chronic and complex disease characterized by excessive or abnormal accumulation of body fat that may impair health. According to the World Health Organization (WHO), obesity in adults is commonly diagnosed using Body Mass Index (BMI), where a BMI of 30 kg/m² or higher indicates obesity. Recent global health reports emphasize that obesity is not merely a lifestyle issue, but a multifactorial disease influenced by genetic, metabolic, behavioral, environmental, and socioeconomic factors. The condition has become one of the most significant global public health challenges because its prevalence continues to rise rapidly across all age groups and countries. More than one billion people worldwide are currently living with obesity, and the disease is strongly associated with serious noncommunicable diseases such as type 2 diabetes, cardiovascular diseases, hypertension, and several cancers, resulting in increased mortality, reduced quality of life, and substantial economic burdens on healthcare systems worldwide(World Heath Organization ,2026).

Recent statistics on the prevalence of obesity:

Recent global statistics indicate that obesity has become one of the fastest-growing public health challenges worldwide. According to the latest data from the World Health Organization (WHO), approximately 1 in every 8 people globally was living with obesity in 2022, with more than 890 million adults classified as obese. In addition, around 43% of adults worldwide were overweight, reflecting a dramatic increase compared with previous decades. The WHO also reported that global adult obesity rates have more than doubled since 1990, while obesity among adolescents has increased nearly fourfold, demonstrating the rapid worldwide spread of this chronic disease(Chrysoula Boutari [1], Christos S Mantzoros,2022).

Recent 2026 reports from the World Obesity Federation emphasize that obesity prevalence continues to rise globally and may affect nearly half of the world's population by 2035 if effective interventions are not implemented. Current estimates indicate that more than one billion people worldwide are living with obesity, while nearly three billion people are either overweight or obese. The highest prevalence rates are observed in several high-income and middle-income countries, although rapid increases are also occurring in low-income regions. These statistics highlight the urgent need for international public health strategies aimed at improving nutrition, increasing physical activity, and reducing the global burden of obesity-related diseases(World Heath Organization ,2026).

The role of nutrition in treating obesity:

Nutrition is considered one of the most effective therapeutic approaches in the treatment and long-term management of obesity. Recent scientific evidence demonstrates that calorie-controlled diets rich in fruits, vegetables, whole grains, and lean proteins can significantly reduce body weight and improve metabolic health outcomes. Research published in *Current Nutrition Reports* in 2026 emphasized that dietary habits directly influence the gut–brain axis and gut microbiota, both of which play important roles in appetite regulation, energy balance, and fat accumulation. Nutritional interventions that improve gut microbiota composition may therefore contribute to sustainable weight loss and better obesity management outcomes(Arellano-García; Portillo; Hadjihambi; Martínez & Milton-Laskibar , 2026).

Recent studies also indicate that personalized nutrition has become increasingly important in obesity treatment. A 2026 review published in *Obesity Medicine* reported that integrating precision nutrition with modern obesity therapies can improve long-term weight-loss maintenance and reduce the risk of weight regain. The review highlighted that individualized dietary strategies based on genetics, lifestyle, metabolism, and gut microbiota may enhance treatment effectiveness and support sustainable obesity management. Furthermore, researchers emphasized that nutritional therapy remains essential even when pharmacological treatments such as GLP-1 receptor agonists are used(Nicoletti ; De Lara ; Martinez,2026).

In addition, recent nutritional research has focused on the role of micronutrients and dietary quality in obesity treatment. A 2026 study published in the journal *Nutrients* showed that individuals with obesity are at increased risk of micronutrient deficiencies, particularly during rapid weight-loss therapies. The study stressed the importance of balanced nutritional intake and continuous dietary monitoring to prevent nutritional deficiencies and maintain healthy body composition during obesity treatment. Similarly, evidence published in the *International Journal of Obesity* in 2026 suggested that certain vitamins and bioactive nutrients may have anti-inflammatory and anti-adipogenic effects that support obesity reduction and metabolic improvement. These findings confirm that proper nutrition is a cornerstone of comprehensive obesity management strategies(Koceva; Janež; Pečko; Jensterle,2026).

- Low-Carb Diets:

Low-carbohydrate diets (Low-carb diets) are nutritional approaches that limit carbohydrate intake while increasing the proportion of proteins and fats in the diet. These dietary patterns have become widely studied for their role in weight reduction and metabolic health improvement. A recent systematic review published in Nutrition in 2026 reported that plant-based low-carbohydrate and ketogenic diets significantly improved body weight, glycemic control, and lipid profiles in individuals with obesity and metabolic disorders. The review also indicated that moderate low-carb interventions were associated with better long-term adherence and sustainability compared with more restrictive ketogenic diets(Mazzola ; Rondanelli ; Cabrini ; Perna,2026).

Recent clinical studies have also highlighted the effectiveness of low-carbohydrate diets in obesity and type 2 diabetes management. A 2026 review published in Frontiers in Nutrition demonstrated that low-carb dietary patterns significantly improve metabolic markers such as triglyceride levels, HDL cholesterol, and glycemic control compared with conventional low-fat diets. Researchers noted that these diets may enhance satiety and reduce hunger, making them beneficial for long-term weight reduction. Furthermore, low-carb interventions were associated with decreased visceral fat accumulation and improved cardiovascular risk profiles in individuals with obesity(Anagnostou; Larumbe-Zabala; Fiore; Roberts & Naclerio, 2026).

Despite their potential benefits, experts emphasize that low-carbohydrate diets should be carefully planned to ensure nutritional adequacy and sustainability. According to a 2026 article published in the International Journal of Obesity, excessively restrictive carbohydrate intake may lead to inadequate fiber, vitamin, and mineral consumption if healthy food choices are not maintained. Therefore, healthcare professionals recommend focusing on nutrient-dense carbohydrate sources such as vegetables, legumes, and whole grains while avoiding highly processed foods. The study also stressed that individualized dietary planning and professional nutritional counseling are essential for maximizing the health benefits and safety of low-carb diets in obesity treatment Stein ; Garbelotto ; Marcadenti ; Burgel ; Teixeira ; Veleda ;da Silva ; Gottschall ; Waclawovsky ; Peres ,2026).

Balanced Diets:

Balanced diets are dietary patterns that include appropriate proportions of macronutrients (carbohydrates, proteins, and fats) together with essential vitamins, minerals, and dietary fiber to maintain energy balance and overall health. Recent evidence from peer-reviewed nutrition literature published in 2026 emphasizes that balanced dietary approaches are considered a cornerstone in the management of obesity because they help regulate caloric intake while ensuring nutritional adequacy. A 2026 review in *Dietetics* highlights that obesity is fundamentally driven by chronic energy imbalance, and structured balanced diets help restore this equilibrium by promoting sustainable eating habits rather than extreme restriction(Peracchia; Rustichelli; Avallone,2026).

From a clinical perspective, balanced diets are strongly associated with improvements in body weight regulation and metabolic health. A 2026 systematic review in *Frontiers in Nutrition* found that dietary interventions combining diverse food groups—especially whole grains, fruits, vegetables, lean proteins, and healthy fats—were more effective for long-term obesity management than restrictive or single-nutrient approaches. These diets improve satiety, reduce overeating, and enhance adherence to treatment plans, which are key factors in preventing weight regain. The same evidence base suggests that balanced diets also contribute to better lipid profiles, glucose control, and reduced inflammation in individuals with obesity(Salem; Ammar; Trabelsi; Boukhris ; Heydenreich; ALi Ghazzawi; Amawi ; Grosso ; Zmijewski ;Jahrami; Husain; Chtourou; Schöllhorn,2026).

Furthermore, recent 2026 research indicates that balanced diets are increasingly integrated into personalized nutrition strategies for obesity treatment. A study in *Genes & Nutrition* shows that individualized balanced dietary plans tailored to metabolic and lifestyle factors can significantly improve weight loss outcomes and support long-term weight maintenance. These approaches recognize that no single diet fits all individuals; instead, balanced nutrition is adapted to ensure adequate nutrient intake while maintaining a controlled energy deficit. This makes balanced diets a sustainable and scientifically supported foundation for obesity management in both clinical practice and public health interventions(Duc; Di Khanh;Khoa; Chi & Huyen,2026).

Bariatric surgery:

Bariatric surgery (metabolic surgery) is a medical intervention used to treat severe obesity by altering the digestive system to achieve significant and sustained weight loss. It is generally recommended for individuals with severe obesity who have not achieved adequate results through lifestyle or pharmacological treatments. Recent evidence published in 2026 highlights that bariatric procedures such as sleeve gastrectomy and Roux-en-Y gastric bypass remain the most effective long-term treatment options for morbid obesity, leading to substantial reductions in body weight and improvement in obesity-related comorbidities. A comprehensive 2026 review in Obesity Surgery confirmed that bariatric surgery produces durable weight loss and long-term metabolic benefits extending beyond 10 years in many patients(Noel; Cazeres; Lutfi; Nocca(2026).

The importance of bariatric surgery in global health is strongly linked to its ability to improve or resolve serious obesity-related diseases. A 2026 systematic review published in the International Journal of Obesity demonstrated that bariatric surgery significantly improves type 2 diabetes remission rates, hypertension control, and cardiovascular risk factors compared with non-surgical treatments. The study also reported that weight loss after surgery is not only substantial but also sustained over long follow-up periods, making it a powerful intervention for reducing obesity-related mortality and disability worldwide(Hedberg; Näslund; Ottosson & Stenberg,2026).

In addition to metabolic improvements, bariatric surgery has been shown in 2026 research to enhance overall quality of life and reduce long-term healthcare burden. Studies published in Obesity Surgery indicate that patients undergoing metabolic bariatric procedures experience improvements in psychological well-being, mobility, and social functioning due to significant weight reduction and comorbidity control. Furthermore, recent position statements from international surgical associations emphasize that bariatric surgery remains a cornerstone therapy for severe obesity, especially when combined with lifestyle and nutritional interventions to ensure long-term success.

Research Problem:

- Are low-carbohydrate diets more effective in the long run? And how do post-surgical nutritional interventions affect outcomes?

Objectives:

- Comparing the long-term effectiveness of low-carbohydrate versus.
- balanced diets; assessing the sustainability of each diet.
- analyzing the outcomes of dietary interventions following bariatric surgery.
- presenting a case study to illustrate practical application.

Research Questions:

- Do low-carbohydrate diets lead to greater long-term weight loss?
- What are the differences in adherence requirements between the two diets?
- What impact does nutrition after bariatric surgery have on: Weight loss, Nutrient deficiencies, Quality of life?

Literature Review:

1- Obesity:

Obesity is a chronic, multifactorial medical condition characterized by excessive accumulation of body fat that impairs health and increases the risk of metabolic, cardiovascular, and endocrine disorders. Recent scientific literature emphasizes that obesity should not be understood solely as a cosmetic or lifestyle issue, but as a complex disease involving interactions between genetic susceptibility, environmental exposure, neuroendocrine regulation, and behavioral factors. A 2026 conceptual review published in Frontiers in Endocrinology highlights that obesity develops through dysregulation of energy balance mechanisms, including appetite control, insulin signaling, and adipose tissue dysfunction, which together lead to progressive fat accumulation and metabolic complications(Prakash ;Arora;Arora ; Khan,2026).

Contemporary research also shows that the definition of obesity is evolving beyond traditional reliance on Body Mass Index (BMI). A 2026 review in Nature Reviews Endocrinology explains that obesity is better understood as excess or abnormal adiposity that may or may not be accompanied by overt disease, and that fat distribution—especially visceral fat—is a key determinant of health risk. This shift in definition reflects growing evidence that individuals with normal BMI can still have clinically significant fat accumulation and metabolic dysfunction, while some individuals with high BMI may not exhibit immediate complications.

Furthermore, obesity is now widely recognized as a major global health burden due to its strong association with chronic diseases and premature mortality. A 2026 article in Nature Reviews Endocrinology reports that obesity is a major risk factor for conditions such as type 2 diabetes, cardiovascular disease, and early death, driven largely by inflammatory and hormonal pathways linked to excess adipose tissue. This modern understanding positions obesity as a systemic disease requiring comprehensive prevention and treatment strategies that address biological, behavioral, and environmental determinants rather than focusing only on body weight.

Causes (genetic, environmental, behavioral) of obesity:

- Obesity is a complex condition caused by the interaction of genetic, environmental, and behavioral factors. Recent scientific reviews published in 2026 emphasize that genetic predisposition plays a major role in determining susceptibility to obesity. Individuals may inherit gene variants that influence appetite regulation, energy expenditure, fat storage, and hormonal signaling. For example, recent genetic studies highlight that multiple obesity-related genes (such as FTO and MC4R pathways) can significantly increase the risk of weight gain, especially when combined with high-calorie diets and sedentary lifestyles. However, these genetic factors do not act alone but interact strongly with environmental exposures(Bonnefond; Bruner; Grant; Morandi & Froguel,2026).
- Environmental factors are also considered a dominant driver of the global obesity epidemic. A 2026 review published in the *International Journal of Obesity* explains that obesogenic environments—characterized by easy access to energy-dense foods, urbanization, reduced physical activity, and modern sedentary habits—strongly contribute to excessive weight gain. These environmental conditions influence eating behavior and energy balance, often overriding genetic protection against obesity. In addition, long-term exposure to unhealthy food environments can alter metabolic regulation and promote chronic positive energy balance, leading to progressive fat accumulation over time(De Roo;Hartman;Wiertsema & Kretschmer ,2026).
- Behavioral factors represent another crucial cause of obesity and are closely linked with both genetics and environment. A 2026 review in *Bulletin of the National Research Centre* highlights that unhealthy dietary habits, overeating, lack of physical activity, sleep disturbances, and stress are key behavioral contributors to obesity development. These behaviors affect energy intake and expenditure, leading to sustained weight gain when caloric intake exceeds energy needs. Moreover, modern research suggests that behavioral patterns are shaped by psychological, social, and cultural influences, making lifestyle modification a central component in obesity prevention and treatment strategies(Dina; Karamat; Basit;Ahmed; Siddique & Bhutta ,2026).

Health complications of obesity:

- Obesity is strongly associated with numerous serious health complications that affect nearly every organ system in the body. Recent evidence published in 2026 indicates that obesity significantly increases the risk of metabolic disorders such as type 2 diabetes mellitus, dyslipidemia, and insulin resistance. Excess adipose tissue contributes to chronic low-grade inflammation and hormonal imbalance,

which impair glucose metabolism and cardiovascular function. A 2026 review in the *International Journal of Obesity* reported that individuals with obesity are substantially more likely to develop metabolic syndrome and related chronic diseases compared with individuals of normal body weight. Padmapriya;Sadananthan;Michael; Tint; Tan;Chia; Kway; Cai;Toh;Tan; Chong;Lee;Yap; Chong;Godfrey;Eriksson;Bernard;Velan & Müller-Riemenschneider ,2026).

- Cardiovascular and respiratory complications are also among the most important health consequences of obesity. Research published in 2026 in *Frontiers in Cardiovascular Medicine* demonstrated that obesity increases the risk of hypertension, coronary artery disease, heart failure, and stroke through mechanisms involving inflammation, endothelial dysfunction, and increased cardiac workload. Furthermore, obesity is closely linked to obstructive sleep apnea and reduced pulmonary function due to excessive fat accumulation around the thoracic and upper airway structures. These complications negatively affect quality of life and contribute significantly to premature mortality worldwide.

Health complications of obesity:

- Low-carbohydrate diets have become one of the most widely studied nutritional strategies for obesity management because of their effectiveness in promoting weight loss and improving metabolic health. These diets typically reduce carbohydrate intake while increasing protein and healthy fat consumption, encouraging the body to utilize stored fat as a primary energy source. A 2026 review published in Nutrients reported that low-carbohydrate dietary interventions significantly reduced body weight, body fat percentage, and waist circumference in adults with obesity. The study also found improvements in insulin sensitivity and appetite regulation, suggesting that carbohydrate restriction may support both short-term and long-term obesity treatment Chrustek ; Sinkiewicz-Darol ; Łubiech; Olszewska-Słonina; Dombrowska-Pali,2026).

- In addition, plant-based low-carbohydrate and ketogenic diets have recently gained attention as effective approaches for obesity treatment. A 2026 systematic review reported that plant-based low-carbohydrate diets improved weight reduction, HbA1c levels, and lipid profiles in individuals with obesity and metabolic disorders. The review further indicated that moderate plant-based carbohydrate restriction showed better adherence rates than strict ketogenic interventions, suggesting that dietary sustainability plays a major role in successful obesity management. These findings support the growing interest in combining low-carbohydrate nutrition with plant-based dietary patterns to achieve both metabolic and environmental benefits(Mazzola ; Rondanelli ; Cabrini ; Perna ,2026).
- Furthermore, recent evidence suggests that carbohydrate-modified diets may improve obesity-related metabolic complications in both adults and children. Studies published in 2026 found that low-carbohydrate interventions significantly improved insulin sensitivity, waist circumference, and fasting glucose levels among overweight and obese participants. Similar benefits were observed in pediatric populations, where low-carbohydrate diets contributed to reductions in BMI and cardiometabolic risk factors. These findings indicate that controlled carbohydrate intake may represent an effective therapeutic strategy for reducing obesity and preventing associated chronic diseases across different age groups(Fournier ; Moore ; Alghamdi ; Thivel,2026).

Definition (e.g., Keto Diet) of Obesity:

- The ketogenic diet (KD) is defined as a very low-carbohydrate, high-fat, and moderate-protein dietary pattern designed to induce a metabolic state called ketosis, in which the body uses fat rather than glucose as its primary energy source. In recent years, the ketogenic diet has gained significant attention as a therapeutic nutritional approach for obesity management. A 2026 narrative review explained that reducing carbohydrate intake to very low levels decreases insulin secretion and increases fat oxidation, resulting in substantial weight loss and improved metabolic health in obese individuals(Kilian ; Szlęzak ; Tyszka-Czochara ; Filipowicz-Popielarska ; Bronowicka-Adamska ,2026).

- Obesity is a chronic metabolic disorder characterized by excessive accumulation of body fat that negatively affects health and increases the risk of diseases such as type 2 diabetes, cardiovascular disorders, and hypertension. Recent studies in 2026 reported that ketogenic diets may play an important role in obesity treatment by improving body composition, reducing body mass index (BMI), and enhancing glycemic control. Researchers also noted that ketogenic diets can reduce appetite and caloric intake due to the appetite-suppressing effects of ketone bodies, making them an effective strategy for weight management in obese patients(Zhao; Gong; Pang & Zhao,2026).
- Furthermore, modern nutritional research has expanded the definition of ketogenic diets to include plant-based and low-carbohydrate ketogenic variations that aim to improve both health outcomes and long-term dietary adherence. According to a 2026 systematic review, plant-based ketogenic diets combine carbohydrate restriction with nutrient-rich plant foods, offering benefits for obesity reduction, lipid metabolism, and blood glucose regulation. These dietary approaches were found to provide sustainable and clinically effective options for individuals suffering from obesity and related metabolic disorders.(Mazzola ; Rondanelli ; Cabrini ; Perna ,2026).

Mechanism: Insulin reduction for obesity:

- One of the primary mechanisms by which low-carbohydrate and ketogenic diets contribute to obesity reduction is through lowering insulin secretion. Insulin is a key anabolic hormone that promotes glucose uptake and fat storage in adipose tissue. When carbohydrate intake is significantly reduced, blood glucose levels decline, leading to decreased insulin production. A 2026 review explained that lower insulin concentrations enhance lipolysis and stimulate the breakdown of stored triglycerides into fatty acids, allowing the body to use fat as its main energy source. This metabolic shift supports weight loss and reduces adipose tissue accumulation in individuals with obesity. (pubmed.ncbi.nlm.nih.gov(Kilian ; Szlęzak ; Tyszka-Czochara ; Filipowicz-Popielarska ; Bronowicka-Adamska ,2026).

- Recent metabolic studies in 2026 also demonstrated that reducing insulin levels improves insulin sensitivity and decreases chronic inflammation associated with obesity. Hyperinsulinemia is strongly linked to excessive fat accumulation and metabolic dysfunction, particularly in individuals with insulin resistance. Researchers reported that carbohydrate-restricted diets lowered fasting insulin levels and improved markers of metabolic health, including waist circumference, fasting glucose, and lipid profiles. These findings suggest that insulin reduction plays a central role in improving obesity-related metabolic abnormalities and promoting healthier body composition(Fournier ; Moore ; Alghamdi ; Thivel,2026).
- Furthermore, evidence published in 2026 indicated that decreased insulin secretion may influence appetite regulation and energy balance. Lower insulin levels are associated with increased production of ketone bodies, which may suppress hunger and reduce caloric intake. A recent systematic review found that participants following low-carbohydrate ketogenic diets experienced greater satiety and reduced food cravings compared with conventional low-fat diets. This appetite-regulating effect contributes to sustained weight loss and improved adherence to dietary interventions among obese individuals. (Anagnostou; Larumbe-Zabala;Fiore; Roberts & Naclerio,2026).

- Mechanism of Increased fat burning to treat obesity:

Recent research in 2026 demonstrated that low-carbohydrate diets enhance mitochondrial activity and stimulate thermogenesis, both of which contribute to increased fat burning in obese individuals. When carbohydrate intake is restricted, the body increases the oxidation of fatty acids within the mitochondria to meet energy demands. This metabolic state elevates energy expenditure and promotes the reduction of adipose tissue, particularly abdominal fat. A recent systematic review found that ketogenic and low-carbohydrate interventions significantly improved body fat reduction and metabolic flexibility, supporting their effectiveness in obesity management. (Anagnostou; Larumbe-Zabala; Fiore; Roberts ; Naclerio,2026).

- **The concept of the Mediterranean diet:**

The Mediterranean diet is a nutritional pattern traditionally followed in countries surrounding the Mediterranean Sea and is characterized by high consumption of vegetables, fruits, whole grains, legumes, nuts, olive oil, and moderate intake of fish and dairy products. This dietary approach has gained considerable attention for its effectiveness in obesity prevention and metabolic health improvement. A 2026 review reported that adherence to the Mediterranean diet was associated with reductions in body weight, waist circumference, and inflammatory markers among overweight and obese individuals. Researchers suggested that the diet's high fiber content and healthy fat composition contribute to increased satiety and better energy balance(Wang ; Luo ; Tan ; Genlong ; Qu ; Shao ; Fu ; Zhang ,2026).

- **Advantages of obesity treatment: Higher sustainability:**

Higher sustainability in obesity treatment is increasingly associated with integrated and long-term management approaches rather than short-term interventions alone. A 2026 study published in *BMC Public Health* demonstrated that multidisciplinary weight-management programs achieved more durable reductions in body mass index and waist circumference over a 24-month follow-up period compared with routine care. The researchers concluded that combining nutritional counseling, physical activity, behavioral therapy, and continuous medical supervision improves adherence and reduces the likelihood of weight regain, thereby enhancing the long-term sustainability of obesity treatment outcomes. In addition, recent reviews emphasized that modern obesity therapies are most effective when personalized and maintained through continuous follow-up, reflecting the chronic nature of obesity management(Chen; He, Lan; Zhang; Hu & Guo ,2026).

Benefits of a balanced diet for treating obesity:

A balanced diet plays a crucial role in the treatment of obesity by promoting sustainable weight loss and improving overall metabolic health. Recent research published in Discover Public Health in 2025 emphasized that dietary patterns rich in fruits, vegetables, whole grains, lean proteins, and healthy fats can significantly reduce body weight and lower the risk of obesity-related complications such as diabetes and cardiovascular disease. The study also highlighted that balanced nutritional interventions improve satiety, regulate energy intake, and support long-term adherence to healthy eating behaviors, making them more effective for sustainable obesity management. Furthermore, individualized balanced diets were associated with better metabolic outcomes and improved quality of life among obese individuals(Aremu; Akute; Aremu; Zando; Aremu; Nwachukwu; Omosebi; Akute;Oluwole;Barkhadle & Aremu .2025).

Disadvantages of balanced nutrition for treating obesity: slower weight loss:

One of the major disadvantages of balanced nutrition in treating obesity is that weight loss often occurs more slowly compared with intensive medical or surgical interventions. A 2025 review published in Nutrients explained that although balanced dietary programs improve overall health and support gradual fat reduction, the pace of weight loss may be insufficient for individuals seeking rapid results or those with severe obesity. Slow progress can negatively affect patient motivation and adherence, increasing the likelihood of discontinuing treatment before achieving long-term goals. The review also noted that metabolic adaptation during calorie reduction may further slow weight reduction over time, making sustained lifestyle commitment essential for successful obesity management (Praštalo ; Pokimica ; Arsić ; Ilich ; Vučić,2025).

Disadvantages of balanced nutrition in treating obesity: a long-term comparison:

Another disadvantage of balanced nutrition in treating obesity is that its long-term effectiveness may vary considerably among individuals when compared with more intensive interventions. A 2025 comparative study published in *Obesity Reviews* found that although balanced dietary approaches are safer and easier to maintain than restrictive diets, some patients experience gradual weight regain over extended follow-up periods due to inconsistent adherence and metabolic adaptation. The study also indicated that long-term dietary management alone may not produce sufficient results for individuals with severe obesity or complex metabolic conditions, who often require combined

therapeutic approaches such as behavioral therapy or pharmacological support. These findings suggest that balanced nutrition, while beneficial for overall health, may have limitations as a standalone long-term obesity treatment strategy(Ajoolabady; Pratico;Dunn; Lip; Ren,2024).

Results of the Research Studies (RCTs):

Recent randomized controlled trials (RCTs) have provided strong evidence supporting the effectiveness of modern obesity treatments in reducing body weight and improving metabolic health outcomes. A 2025 systematic review and meta-analysis published in Nature Medicine analyzed 56 randomized controlled trials involving more than 60,000 participants and found that pharmacological therapies such as semaglutide and tirzepatide produced significant and sustained weight reduction compared with placebo treatments. The review also reported improvements in blood glucose levels, blood pressure, and lipid profiles, highlighting the clinical value of these interventions in obesity management. Furthermore, lifestyle-based RCTs demonstrated that structured dietary and behavioral programs contribute to meaningful long-term weight control and better adherence among obese individuals(McGowan; Ciudin; Baker; Busetto; Dicker; Frühbeck; Goossens; Monami; Sbraccia;Martinez-Tellez; Woodward & Yumuk ,2025).

Weight Regain Rates:

Weight regain (WR) after intentional weight loss is increasingly recognized as a **common long-term physiological and behavioral challenge**, rather than a failure of treatment. Recent evidence from 2025 highlights that even after highly effective interventions such as bariatric surgery or pharmacological weight loss, a substantial proportion of individuals experience partial or significant regain over time. This phenomenon is linked to complex biological adaptations—such as hormonal changes (e.g., reduced satiety signaling), metabolic adaptation (lower resting energy expenditure), and increased appetite—along with behavioral and environmental factors that promote energy imbalance. A 2025 narrative review reported that weight regain after bariatric procedures may affect a large subset of patients over long-term follow-up, with estimates reaching up to 20–30% or more depending on surgical type and follow-up duration(Cao;BA; Kazi; BA; Kazi; BA; ; Merchant;MD; FACS; Jawed; MD;FACS;FASMBS,2025).

Adherence to Obesity Treatment:

Adherence (defined as the extent to which individuals follow prescribed medical, dietary, or behavioral recommendations) is a central determinant of long-term success in weight management and chronic disease interventions. Recent 2025 evidence emphasizes that adherence is a multidimensional construct, influenced by behavioral consistency (e.g., diet and physical activity compliance), psychological motivation, and the design of intervention programs. Importantly, adherence is not static; it fluctuates over time and is strongly affected by environmental and social support factors. A 2025 scoping review on behavioral weight management highlighted that higher adherence—particularly through self-monitoring, structured guidance, and professional supervision—is consistently associated with improved weight outcomes and reduced dropout rates in lifestyle interventions(Wang; Rojo-Tirado; Benito; Rubio-Arias,2025).

Moreover, recent studies in digital health interventions show that adherence can be enhanced through technology-based strategies such as reminders, feedback systems, and behavior tracking tools, which help maintain engagement over extended periods. Overall, current 2025 research indicates that improving adherence is essential not only for achieving initial weight loss but also for preventing relapse and sustaining long-term health benefits(Praštalo; Pokimica; Arsić; Ilich; Vučić,2025).

Bariatric Surgery:

Bariatric surgery is widely recognized in recent 2025 medical literature as one of the most effective long-term interventions for severe obesity, particularly when lifestyle and pharmacological approaches fail. Contemporary evidence shows that procedures such as sleeve gastrectomy and Roux-en-Y gastric bypass can produce substantial and sustained weight loss, along with significant improvement or remission of obesity-related comorbidities. However, recent studies also emphasize that long-term success after bariatric surgery depends heavily on postoperative behavioral adherence, nutritional follow-up, and lifestyle modification. A large 2025 meta-analysis reported that bariatric surgery results in significantly greater long-term weight reduction compared with non-surgical approaches, with patients maintaining a meaningful percentage of total body weight loss over 5 years or more, although variability in outcomes remains due to differences in follow-up and adherence levels(Cunningham ; Bloomfield ; Chen ; Foshag ; Azagury ; Alimi ; Prindeze ,2025).

Furthermore, a 2025 systematic review highlights that while bariatric procedures are highly effective, their long-term success is influenced by patient compliance with dietary guidelines, physical activity, and continuous medical monitoring, which are essential to minimize weight regain and optimize metabolic outcomes(MacVicar; Lucocq; Geropoulos; Lamb; Robertson,2025). Overall, current evidence reinforces that bariatric surgery is not a standalone cure but part of a comprehensive, long-term management strategy for obesity requiring sustained adherence and multidisciplinary care.

Types of bariatric surgery: Gastric bypass:

Bariatric surgery is a group of metabolic procedures used to treat severe obesity, and **Roux-en-Y gastric bypass (RYGB)** remains one of the most widely studied and effective types. In this technique, a small gastric pouch is created and directly connected to the jejunum, bypassing most of the stomach and part of the small intestine, which leads to both **restriction of food intake and malabsorption**. Recent 2025 systematic reviews confirm that gastric bypass produces significant and sustained weight loss compared with other bariatric procedures, along with strong improvements in metabolic conditions such as type 2 diabetes and dyslipidemia. Evidence also shows that RYGB achieves greater long-term weight reduction and higher remission rates of obesity-related diseases, although it may carry a higher need for lifelong nutritional monitoring due to micronutrient deficiencies. A 2025 meta-analysis of long-term outcomes reported that patients undergoing gastric bypass maintain substantial total weight loss over several years, supporting its status as a "gold standard" bariatric procedure in appropriate candidates(Delgado ;de Souza ; Pompeu ; Ogawa ;Oliveira ; Valladão ; Marques ,2025).

Types of bariatric surgery: Gastric bypass:

Bariatric surgery includes several techniques, and Roux-en-Y gastric bypass (RYGB) is one of the most established and effective procedures for the treatment of severe obesity. This operation works by creating a small gastric pouch and connecting

it directly to the jejunum, which reduces food intake and decreases nutrient absorption. Recent 2025 evidence shows that gastric bypass remains highly effective in achieving substantial and sustained weight loss, with strong long-term improvements in obesity-related conditions such as type 2 diabetes, hypertension, and dyslipidemia. A large 2025 meta-analysis reported that RYGB continues to demonstrate durable weight reduction and significant metabolic benefits even beyond five years of follow-up, confirming its status as a gold-standard bariatric procedure for appropriately selected patients. However, the same studies emphasize that long-term success depends on lifelong nutritional monitoring and adherence to dietary and lifestyle recommendations, as postoperative deficiencies and weight variability may occur if follow-up care is inadequate(Cunningham ; Bloomfield ; Chen ;C Foshag ; Azagury ; Alimi ; Prindeze ,2025).

Types of bariatric surgery:Sleeve gastrectomy :

Sleeve gastrectomy is one of the most commonly performed types of bariatric surgery and has become a first-line surgical option for patients with severe obesity. The procedure involves the surgical removal of approximately 70–80% of the stomach, leaving a narrow gastric "sleeve" that limits food intake and reduces hunger by decreasing ghrelin hormone production. Recent 2025 systematic reviews and meta-analyses confirm that sleeve gastrectomy produces significant and sustained weight loss, along with meaningful improvements in obesity-related conditions such as type 2 diabetes, hypertension, and dyslipidemia. However, current evidence also highlights that long-term outcomes may vary, with some patients experiencing weight stabilization or partial weight regain over time, especially without strict dietary adherence and follow-up care. Comparative studies published in 2025 indicate that while sleeve gastrectomy is slightly less metabolically potent than gastric bypass in some cases, it remains highly effective with a lower risk of malabsorption-related complications, making it a widely preferred option in modern bariatric practice (Delgado ;de Souza ; Pompeu ; Ogawa ;Oliveira ; Valladão ; Marques ,2025).

Types of bariatric surgery: And their effect on weight loss:

Bariatric surgery includes several procedures designed to achieve significant and sustained weight loss by modifying the stomach and/or intestines, and the most common types are sleeve gastrectomy and Roux-en-Y gastric bypass. Current 2025 evidence shows that these procedures produce substantial reductions in total body weight, especially within the first 1–2 years after surgery, followed by long-term maintenance depending on lifestyle adherence. A recent meta-analysis published in 2025 comparing bariatric techniques reported that patients undergoing gastric bypass achieved higher long-term total body weight loss (around 30% or more) compared to sleeve gastrectomy, which typically results in slightly lower but still clinically significant weight reduction (around 25–30% total body weight loss(Permata; Halim; Aditya; Wibowo; Shantidewi ; Rachman; Indrianto; Budianto ,2025).

Additionally, comparative studies indicate that gastric bypass may provide stronger metabolic effects, particularly for conditions like type 2 diabetes, while sleeve gastrectomy offers effective weight loss with a lower risk of malabsorption-related complications. Overall, 2025 research confirms that both procedures are highly effective for obesity management, but their impact on weight loss varies depending on surgical type, patient characteristics, and long-term adherence to dietary and lifestyle changes(Lei; Lei;Chen; Wang;Song;Feng;Wu; Jia;Hu & Tian,2024).

Nutritional interventions after bariatric surgery:

Nutritional interventions after bariatric surgery are considered a fundamental component of long-term patient management because surgical procedures such as sleeve gastrectomy and gastric bypass significantly alter food intake, digestion, and nutrient absorption. Recent 2025 evidence emphasizes that postoperative nutrition must focus on high-protein intake, lifelong vitamin and mineral supplementation, and structured dietary progression to prevent deficiencies and support sustained weight loss. A 2025 systematic review reported that patients after bariatric surgery commonly develop micronutrient deficiencies (such as vitamin D, vitamin B12, iron, calcium, and zinc) if nutritional support and supplementation are not adequately maintained (El-Masry;Mahmoud; Mohamed ;Elraggal; Elkholy & Abokhozima .2025).

Moreover, updated clinical guidelines highlight that structured dietary counseling and individualized nutritional monitoring significantly improve body composition outcomes and help preserve fat-free mass during rapid weight loss phases(Abiri ; Valizadeh ; Seifi ; Amini ; Haidari ,2026).

In addition, recent 2025 research shows that pre- and post-operative nutritional strategies, including protein optimization and staged diet progression, are associated with improved recovery, reduced complications, and better long-term weight maintenance after metabolic surgery(Soliman;Mattar; Mostafa; Saweris;Bin Subih;Kaddah & Abdelwahab (2025). Overall, current evidence confirms that nutritional interventions are not optional but essential to ensure safe and effective long-term outcomes following bariatric surgery.

Stages of nutrition (liquids → purees → solid foods) for treating obesity:

- Nutritional management after bariatric surgery follows a **progressive staged dietary approach** designed to promote healing, prevent gastrointestinal complications, and facilitate gradual adaptation to reduced stomach capacity. Recent 2025 clinical guidelines describe the postoperative diet as typically advancing through three major phases: **clear and full liquids, pureed or soft foods, and finally regular solid foods**. During the initial liquid phase, patients consume protein-rich fluids and adequate hydration to minimize stress on the surgical site while preventing dehydration. This is followed by the pureed stage, where soft blended foods are introduced gradually to improve tolerance and ensure sufficient nutrient intake. Eventually, patients transition to solid foods with an emphasis on small portions, high protein intake, and avoidance of high-sugar and high-fat meals. A 2025 review highlighted that adherence to this staged nutritional progression is associated with improved gastrointestinal tolerance, reduced postoperative complications, and better long-term weight management outcomes.Furthermore, recent evidence stresses that individualized dietary education and close nutritional monitoring during these phases are essential to reduce nutrient deficiencies and support sustainable postoperative recovery(Abiri ; Valizadeh ; Seifi ; Amini ; Haidari ,2026).
- After bariatric surgery, nutritional therapy follows a **gradual staged progression from liquids to pureed foods and finally to solid foods** in order to support healing,

improve food tolerance, and promote sustainable weight loss. Recent evidence from 2024–2026 indicates that the first postoperative phase usually consists of clear and full liquids to maintain hydration and reduce stress on the gastrointestinal tract. This is followed by a pureed or soft-food stage, during which patients gradually adapt to thicker textures while focusing on high-protein intake and small meal portions. Eventually, patients transition to regular solid foods approximately 6–8 weeks after surgery, depending on individual tolerance and medical guidance. Clinical guidelines published in 2025 emphasize that adherence to these dietary stages is essential for preventing complications such as nausea, vomiting, dumping syndrome, and nutritional deficiencies(Mayo Clinic Staff,2025).

- Recent reviews also highlight that progression through the nutritional stages should be individualized according to patient recovery and tolerance rather than following a rigid timeline. A comprehensive 2024 review on nutritional management after bariatric surgery explained that early introduction of liquids within 24–48 hours after surgery supports hydration and recovery, while gradual advancement to pureed and soft foods minimizes gastrointestinal discomfort and protects surgical integrity. Moreover, structured dietary progression has been associated with better preservation of lean body mass and improved long-term weight control outcomes(Frias-Toral; Chapela; Gonzalez; Martinuzzi; Locatelli; Llobera; Manrique; Sarno; Mingo; Marchese; Cuomo; Romaniello; Perna; Giordano; Santella; Schiavo,2025).
- Furthermore, studies from 2025 and 2026 stress that nutritional progression is not only a healing strategy but also an important behavioral intervention that helps patients adapt to lifelong eating modifications after bariatric surgery. Educational support during the liquid, pureed, and solid-food phases improves adherence and reduces the likelihood of postoperative complications and weight regain. Updated postoperative nutrition recommendations also emphasize slow eating, adequate hydration, protein prioritization, and gradual texture advancement as key components for long-term obesity treatment success(Moize; Laferrère;Shapses ,2024).

The role of dietary supplements: iron, vitamin B12, and calcium in treating obesity:

- Iron, vitamin B12, and calcium supplements play a critical role in the nutritional management of patients undergoing bariatric surgery for obesity treatment. Recent evidence from 2024–2026 demonstrates that bariatric procedures, particularly Roux-en-Y gastric bypass and sleeve gastrectomy, can significantly impair the absorption of essential micronutrients because of reduced gastric volume, altered digestion, and bypass of absorption sites in the small intestine. As a result, iron deficiency anemia, vitamin B12 deficiency, and calcium imbalance are among the most common long-term complications after surgery. A 2025 prospective study found that deficiencies in iron and vitamin B12 increased significantly during long-term follow-up after bariatric surgery, highlighting the necessity of lifelong supplementation and regular biochemical monitoring(Humięcka; Sawicka; Sawicka; Kędzierska; Binda; Jaworski; Tarnowski; Jankowski, 2025).
- Vitamin B12 supplementation is particularly important because bariatric surgery reduces intrinsic factor production and gastric acid secretion, both of which are essential for B12 absorption. Recent 2025 systematic reviews reported that patients who do not adhere to postoperative supplementation protocols are at increased risk of neurological symptoms, anemia, fatigue, and impaired metabolic recovery. In addition, iron supplementation is strongly recommended because decreased gastric acidity and reduced intestinal absorption frequently lead to chronic iron deficiency, especially in women of reproductive age. Current clinical strategies emphasize individualized supplementation plans and periodic laboratory evaluation to optimize obesity-treatment outcomes and prevent nutritional complications(El-Masry;Mahmoud; Mohamed ;Elraggal; Elkholy & Abokhozima ,2025).
- Calcium supplementation, usually combined with vitamin D, is also essential after bariatric surgery to preserve bone health and reduce the risk of osteoporosis and metabolic bone disease during rapid weight loss. Recent reviews published in 2025 and 2026 emphasize that calcium citrate is preferred due to its better absorption after gastric surgery. Long-term evidence further indicates that appropriate supplementation with iron, vitamin B12, and calcium not only prevents deficiencies but also supports energy metabolism, physical recovery, and maintenance of healthy weight loss after obesity surgery. Therefore, nutritional supplementation is considered a lifelong therapeutic component of obesity management after bariatric procedures(Giedzicz; Zubrzycki; Łukaszewicz; Głuszyńska; Hady,2026).

Potential problems of obesity resulting from malnutrition Dumping syndrome:

- Malnutrition is considered one of the major potential complications associated with obesity treatment after bariatric surgery, particularly when postoperative dietary recommendations and supplementation are not properly followed. Recent evidence from 2024–2026 demonstrates that restrictive and malabsorptive procedures can significantly impair the absorption of proteins, vitamins, and minerals, leading to deficiencies in iron, vitamin B12, calcium, vitamin D, and other micronutrients. A 2025 systematic review reported that long-term nutritional deficiencies remain highly prevalent after bariatric surgery and may contribute to anemia, bone disorders, muscle weakness, fatigue, and impaired metabolic recovery if patients do not maintain lifelong nutritional monitoring and supplementation(El-Masry;Mahmoud; Mohamed ;Elraggal; Elkholy & Abokhozima ,2025).Furthermore, researchers emphasize that rapid weight loss combined with inadequate protein intake can increase the risk of sarcopenia and loss of lean body mass, making individualized nutritional care essential for successful obesity treatment.

- Dumping syndrome is another common complication that may occur after bariatric procedures, especially Roux-en-Y gastric bypass. It develops when food, particularly meals high in sugar or refined carbohydrates, passes too rapidly from the stomach into the small intestine. Recent 2025 reviews describe dumping syndrome as a condition characterized by gastrointestinal and vasomotor symptoms such as abdominal pain, nausea, diarrhea, dizziness, palpitations, sweating, and weakness. Early dumping usually occurs within 30 minutes after eating due to rapid gastric emptying, whereas late dumping may occur 1–3 hours later as a result of reactive hypoglycemia. Current evidence indicates that dumping syndrome can negatively affect quality of life and nutritional status, although it may also contribute indirectly to weight reduction by discouraging excessive intake of sugary foods(Cano ; Rodríguez; Duran; Cano, 2025).

- Recent studies from 2025 and 2026 emphasize that the prevention and management of dumping syndrome and malnutrition rely primarily on nutritional interventions and patient adherence to dietary guidelines. Recommended strategies include consuming small frequent meals, increasing protein and fiber intake, avoiding high-sugar foods, separating fluids from meals, and maintaining lifelong vitamin and mineral supplementation. A 2025 narrative review on nutritional approaches to dumping syndrome concluded that individualized dietary management remains the first-line treatment and can significantly reduce symptom severity and improve long-term postoperative outcomes. Additionally, ongoing nutritional counseling and follow-up are strongly recommended to minimize the combined risks of nutrient deficiencies, gastrointestinal complications, and weight regain after bariatric surgery(Scarpellini ; Siquini ,2025).

Methodology: Study Design:

This study will adopt a **case study design** with a **comparative longitudinal approach** to evaluate the effectiveness of low-carbohydrate diets versus balanced diets in the long-term management of obesity, in addition to assessing nutritional interventions after bariatric surgery. The study will focus on a detailed clinical follow-up of obese patients undergoing different dietary strategies and postoperative nutritional management over an extended period of time.

Participants will be divided into two main groups according to the dietary intervention received:

1. Patients following a **low-carbohydrate diet**.
2. Patients following a **balanced diet** based on standard nutritional recommendations.

In addition, a subgroup of participants who have undergone bariatric surgery will be evaluated to assess the effectiveness of postoperative nutritional interventions, including staged dietary progression (liquids, pureed foods, and solid foods) and micronutrient supplementation such as iron, vitamin B12, and calcium.

The study will use a **longitudinal follow-up design** to monitor changes in body weight, body mass index (BMI), adherence, nutritional status, and weight regain over time. Data collection will include clinical measurements, dietary assessments, laboratory investigations, and patient interviews. The comparative nature of the study will allow evaluation of differences in long-term outcomes between low-carbohydrate and balanced dietary patterns, as well as the role of nutritional interventions after bariatric surgery in sustaining weight loss and preventing complications.

The methodology is considered appropriate because it enables comprehensive observation of real-life patient experiences and long-term dietary outcomes within obesity treatment programs.

Methodology：Study Design：

This study will employ a **systematic review methodology** to evaluate the long-term effectiveness of low-carbohydrate diets compared with balanced diets in the treatment of obesity, as well as nutritional interventions following bariatric surgery. The review will be conducted according to internationally recognized systematic review principles to ensure transparency, reliability, and comprehensive evidence synthesis.

Search Strategy：

A comprehensive literature search will be performed using electronic scientific databases, including **PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar**. The search will focus on studies published between **2024 and 2026** in the English language. Keywords and Medical Subject Headings (MeSH) terms will include combinations of the following terms: *obesity*, *low-carbohydrate diet*, *balanced diet*, *weight loss*, *weight regain*, *bariatric surgery*, *nutritional interventions*, *micronutrient supplementation*, *dumping syndrome*, and *dietary adherence*. Boolean operators such as AND and OR will be used to refine the search process.

Inclusion and Exclusion Criteria：

The review will include randomized controlled trials, cohort studies, systematic reviews, meta-analyses, and clinical guidelines related to obesity treatment and postoperative bariatric nutritional care. Studies will be included if they:

- Investigate low-carbohydrate diets or balanced diets in obesity management.
- Evaluate long-term weight loss outcomes or weight regain.
- Examine nutritional interventions after bariatric surgery.
- Are published between 2024 and 2026.
- Are available in full-text English versions.

Studies will be excluded if they:

- Focus on pediatric populations only.
- Lack clear methodological quality.
- Are conference abstracts without full data.
- Include non-scientific or non-peer-reviewed sources.
- Depend primarily on World Health Organization references.

Data Collection and Analysis:

Relevant data will be extracted using a structured data extraction form, including study author, publication year, study type, sample size, intervention type, duration, outcomes, and key findings. The collected evidence will then be analyzed qualitatively through thematic synthesis to compare the effectiveness of low-carbohydrate and balanced diets and to evaluate postoperative nutritional strategies after bariatric surgery.

Quality Assessment:

The methodological quality of included studies will be assessed using standardized critical appraisal tools appropriate to the study design, such as the PRISMA framework for systematic reviews and the Newcastle–Ottawa Scale or Cochrane Risk of Bias Tool for clinical studies.

Ethical Considerations:

As this study is based on previously published literature and does not involve direct human participation, ethical approval is not required. However, all sources will be properly cited to maintain academic integrity and avoid plagiarism.

Methodology:Study Design:

This research will utilize a **Case Study design** to investigate the long-term effectiveness of low-carbohydrate diets compared with balanced diets in the treatment of obesity, as well as the role of nutritional interventions after bariatric surgery. The case study approach is appropriate because it allows an in-depth exploration of individual patient experiences, behavioral adherence, dietary responses, and clinical outcomes over time within a real-life context.

Study Setting and Participants:

The study will be conducted in a nutrition and obesity management clinic and will include a purposive sample of adult patients diagnosed with obesity. Participants will be selected based on their treatment pathway and categorized into the following cases:

1. Patients following a **low-carbohydrate diet** for long-term obesity management.
2. Patients following a **balanced diet** based on standard dietary recommendations.
3. Patients who underwent **bariatric surgery** and received postoperative nutritional interventions.

Cases will be selected according to inclusion criteria such as adult age, confirmed obesity diagnosis (BMI $\geq$30 kg/m^2), and commitment to follow-up for a defined study period.

Data Collection:

Data will be collected through multiple methods to ensure comprehensive understanding of each case. These methods will include:

- Clinical records review.
- Anthropometric measurements such as body weight and Body Mass Index (BMI).
- Dietary assessment tools including 24-hour dietary recall and food frequency questionnaires.
- Laboratory investigations related to nutritional status (iron, vitamin B12, calcium, and vitamin D).
- Semi-structured interviews to assess dietary adherence, lifestyle behaviors, and patient experiences.

For bariatric surgery cases, postoperative nutritional stages (liquids, pureed foods, and solid foods) and supplement adherence will also be evaluated.

Follow-Up Procedure:

Participants will be followed longitudinally over a specified period to monitor changes in weight loss, weight regain, nutritional status, and adherence to dietary interventions. Follow-up assessments will be conducted periodically to compare short- and long-term outcomes between the different dietary approaches.

Data Analysis:

The collected data will be analyzed using a qualitative and descriptive comparative approach. Clinical outcomes, adherence patterns, nutritional complications, and patient experiences will be compared across cases to identify similarities, differences, and factors influencing long-term obesity management success.

Ethical Considerations:

Informed consent will be obtained from all participants before data collection. Confidentiality and privacy of patient information will be strictly maintained throughout the study, and all collected data will be used solely for academic and research purposes.

Methodology: Data Sources:

The study will rely on both primary and secondary data sources to evaluate the long-term effectiveness of low-carbohydrate diets compared with balanced diets in the treatment of obesity, in

addition to nutritional interventions after bariatric surgery within the framework of a case study approach.

Primary Data Sources:

- Primary data will be collected directly from the selected study participants through:
- Clinical assessments: including measurements of body weight, Body Mass Index (BMI), waist circumference, and follow-up records related to weight changes and obesity management outcomes.
- Dietary assessment tools: such as 24-hour dietary recalls, food frequency questionnaires, and dietary adherence checklists to evaluate participants' nutritional intake and compliance with the prescribed dietary patterns.
- Laboratory investigations: including biochemical indicators related to nutritional status such as iron levels, vitamin B12, calcium, vitamin D, blood glucose, and lipid profile.
- Patient interviews: semi-structured interviews will be conducted to collect information about lifestyle habits, physical activity, eating behaviors, adherence to dietary interventions, and personal experiences with obesity treatment or bariatric surgery.
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- Medical records: postoperative follow-up records for bariatric surgery patients will be reviewed to assess nutritional progression stages (liquids, pureed foods, and solid foods), supplement use, complications, and weight regain patterns.

Secondary Data Sources:

- Secondary data will be obtained from scientific and academic resources to support the theoretical framework and interpretation of findings. These sources will include:
- Peer-reviewed journal articles.
- Systematic reviews and meta-analyses.
- Clinical nutrition and bariatric surgery guidelines.
- Academic books and evidence-based nutrition references.
- Electronic scientific databases such as PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar.

The review of secondary sources will focus primarily on recent studies published between 2024 and 2026 related to obesity management, low-carbohydrate diets, balanced diets, bariatric surgery, postoperative nutritional interventions, adherence, and weight regain.

Data Reliability and Validity:

To ensure the reliability and validity of the collected data, standardized measurement tools and validated dietary assessment methods will be used. Scientific sources included in the study will be selected based on credibility, peer-review status, and relevance to the research objectives.

Methodology: Clinical Trial Design:

This study will employ a **controlled longitudinal clinical trial design** to evaluate the long-term effectiveness of low-carbohydrate diets compared with balanced diets in the treatment of obesity, as well as the effectiveness of nutritional interventions after bariatric surgery. The trial will follow participants over an extended period to assess changes in body weight, metabolic health, dietary adherence, and postoperative nutritional outcomes.

Study Population and Sample:

The study population will consist of adult patients diagnosed with obesity (BMI ≥30 kg/m²) who attend obesity management or bariatric surgery clinics. Participants will be recruited according to predefined inclusion and exclusion criteria. Eligible participants will be divided into the following groups:

1. **Low-carbohydrate diet group:** participants following a reduced-carbohydrate nutritional plan.
2. **Balanced diet group:** participants following a calorie-controlled balanced diet based on standard nutritional recommendations.
3. **Post-bariatric surgery group:** patients receiving structured postoperative nutritional interventions after bariatric surgery.

Participants will be monitored throughout the study period to evaluate both short-term and long-term treatment outcomes.

Intervention Procedures:

The dietary interventions will be implemented under the supervision of qualified nutrition specialists. Individualized meal plans will be provided according to each participant's caloric and nutritional requirements.

- The **low-carbohydrate diet** will emphasize reduced carbohydrate intake with moderate protein and healthy fat consumption.
- The **balanced diet** will include carbohydrates, proteins, and fats in recommended proportions according to established dietary guidelines.
- Bariatric surgery patients will receive staged postoperative nutritional management progressing from liquids to pureed foods and finally to solid foods, in addition to vitamin and mineral supplementation such as iron, vitamin B12, calcium, and vitamin D.

Data Collection:

Clinical and nutritional data will be collected at baseline and during scheduled follow-up visits. Data collection methods will include:

- Anthropometric measurements (weight, BMI, waist circumference).

- Dietary intake assessments using food records and dietary recall tools.
- Laboratory investigations including blood glucose, lipid profile, iron, vitamin B12, calcium, and vitamin D levels.
- Assessment of adherence to dietary interventions and supplement use.
- Monitoring of complications such as nutritional deficiencies, dumping syndrome, and weight regain.

Outcome Measures:

The primary outcomes will include:

- Long-term weight loss effectiveness.
- Changes in BMI and body composition.
- Degree of dietary adherence.
- Incidence of weight regain.

Secondary outcomes will include:

- Nutritional deficiencies.
- Metabolic health improvements.
- Quality of life indicators.
- Postoperative complications after bariatric surgery.

Data Analysis:

Collected data will be statistically analyzed using appropriate software. Comparative analyses will be conducted between groups to determine the effectiveness of low-carbohydrate diets versus balanced diets and to assess the role of nutritional interventions after bariatric surgery. Statistical significance will be determined using appropriate tests such as t-tests, chi-square tests, and analysis of variance (ANOVA).

Ethical Considerations:

Ethical approval will be obtained from the relevant institutional review board before conducting the study. Written informed consent will be obtained from all participants. Participant confidentiality and privacy will be maintained throughout the research process.

Methodology:Selection Criteria:

The study will apply specific inclusion and exclusion criteria to ensure the appropriate selection of participants for evaluating the long-term effectiveness of low-carbohydrate diets versus balanced diets in obesity treatment, as well as nutritional interventions after bariatric surgery within the case study framework.

Inclusion Criteria:

Participants will be included in the study if they meet the following conditions:

- Adults aged 18 years and older.
- Diagnosed with obesity according to Body Mass Index (BMI $\geq$30 kg/m^2).
- Following either a low-carbohydrate diet or a balanced diet for obesity management for a minimum defined period.
- Patients who have undergone bariatric surgery and are receiving postoperative nutritional interventions.
- Ability and willingness to participate in follow-up assessments and interviews throughout the study duration.
- Availability of complete medical and nutritional records relevant to the study objectives.
- Agreement to provide informed consent for participation in the study.

Exclusion Criteria:

Participants will be excluded from the study if they meet any of the following conditions:

- Individuals younger than 18 years old.
- Pregnant or lactating women due to altered nutritional and metabolic requirements.
- Patients with severe chronic illnesses that may independently affect body weight or nutritional status, such as advanced cancer, severe liver disease, or renal failure.
- Individuals with diagnosed eating disorders such as anorexia nervosa or bulimia nervosa.
- Patients using medications known to significantly influence body weight without medical supervision related to obesity treatment.
- Participants who are unable to comply with dietary interventions or follow-up procedures.
- Cases with incomplete clinical, laboratory, or dietary data.

Case Selection Strategy:

A purposive sampling method will be used to select cases that best represent the study objectives. Participants will be categorized according to the type of dietary intervention and bariatric surgery status to allow comparison of long-term outcomes, adherence levels, nutritional complications, and weight regain patterns.

Rationale for Selection Criteria:

These criteria are designed to improve the reliability and validity of the findings by selecting participants whose clinical and nutritional characteristics are directly relevant to obesity management and postoperative bariatric nutritional care. The criteria also help minimize confounding factors that may affect the interpretation of long-term treatment outcomes..

long-term studies (≥ 12 months (Methodology:)

- Long-term studies (≥12 months) are considered essential in evaluating the effectiveness of low-carbohydrate diets compared with balanced diets in obesity treatment because obesity is a chronic condition associated with weight regain and metabolic adaptation over time. In the methodology of this case study, only studies and clinical evidence with a follow-up duration of at least 12 months will be included to ensure the assessment of sustainable weight loss outcomes and long-term dietary adherence. Evidence from randomized controlled trials demonstrated that both low-carbohydrate and balanced diets can produce clinically significant weight reduction over one to two years; however, the differences between the two dietary approaches become less pronounced during long-term follow-up. A major systematic review involving long-term randomized trials found little to no significant difference in body weight reduction between low-carbohydrate and balanced-carbohydrate diets after 12 months or more, despite initial short-term advantages observed with low-carbohydrate interventions.
- The methodological framework of the study will therefore prioritize longitudinal clinical outcomes such as body weight, Body Mass Index (BMI), metabolic markers, dietary adherence, and weight regain patterns across extended follow-up periods. Recent 12-month randomized clinical trials published in 2025 further support the importance of long-term monitoring by showing that healthy low-carbohydrate interventions may improve visceral fat reduction and metabolic parameters during sustained dietary treatment. Nevertheless, researchers emphasized that long-term success depends more on adherence, caloric control, and behavioral consistency than on macronutrient composition alone. These findings justify the inclusion of long-duration studies within the methodology to better evaluate realistic and sustainable obesity treatment outcomes.
- In addition, long-term methodological assessment is particularly important when studying nutritional interventions after bariatric surgery. Postoperative nutritional management requires continuous monitoring for at least 12 months to evaluate nutritional deficiencies, adherence to staged dietary progression (liquids, purees, and solid foods), micronutrient supplementation, and the risk of weight regain. Therefore, the study methodology will include only long-term postoperative evidence to assess how sustained nutritional care influences obesity outcomes after surgery. Current evidence indicates that maintaining structured nutritional follow-up over extended periods improves weight maintenance, metabolic recovery, and prevention of complications such as dumping syndrome and micronutrient deficiencies. Consequently, the inclusion of studies lasting ≥12 months strengthens the validity and reliability of the methodological approach in evaluating the long-term effectiveness of dietary and postoperative nutritional interventions in obesity management.

Case study of a patient who underwent bariatric surgery:

Recent international case studies demonstrate that patients with severe obesity often present with complex metabolic, respiratory, and cardiovascular complications that require multidisciplinary management. A 2025 case report described a 30-year-old female patient with severe obesity (BMI 79.2 kg/m²) complicated by multiple organ failure, respiratory dysfunction, pulmonary hypertension, and metabolic disorders. The patient underwent a comprehensive treatment program including a personalized dietary intervention, behavioral management, and bariatric surgery. The study reported significant improvement in weight, respiratory function, and metabolic health after long-term multidisciplinary treatment, highlighting the importance of combining nutritional and surgical interventions in obesity management(Feng ; Zhang ; Gao ; Ye ; Wang ; Gu ; Peng ,2025).

Another 2025 case report documented a patient with "super-super obesity" (BMI 106.25 kg/m²) who was initially bedridden and suffered from type 2 diabetes and obstructive sleep apnea. The management strategy included a very-low-calorie diet, pharmacological treatment with tirzepatide, and eventual sleeve gastrectomy. The patient achieved substantial preoperative and postoperative weight reduction, improved mobility, and better metabolic control. Researchers emphasized that successful obesity treatment requires continuous nutritional follow-up, dietary adherence, and multidisciplinary cooperation among surgeons, dietitians, and endocrinologists(Daou ; Barajas-Gamboa ; Salloum ; Guerron,2025).

Similarly, a 2025 clinical case involving a heart-transplant recipient with obesity demonstrated the effectiveness of laparoscopic sleeve gastrectomy in improving cardiometabolic outcomes. The patient experienced significant weight loss, improved cardiovascular function, and reduction in obesity-related complications following surgery and postoperative nutritional management. The report concluded that bariatric surgery can be safely and effectively implemented in high-risk obese patients when combined with careful nutritional and medical monitoring(Amini;Moeinvaziri, Hosseini; drissi;Haghighat & Rezaei,2025)..

In another recent case, researchers described a morbidly obese patient (BMI 99 kg/m²) undergoing gastric bypass surgery with specialized perioperative management. The study highlighted the challenges associated with anesthesia, respiratory complications, and postoperative recovery in patients with extreme obesity. Despite these risks, the patient showed positive postoperative outcomes following multidisciplinary surgical and nutritional care (Bassols; Moreno; Vargas; Fierro;Novoa;Ballesta & Ramirez-Paesano ,2025).

Dietary follow-up after bariatric surgery:

Dietary follow-up after bariatric surgery is considered an essential component of long-term obesity management because surgical procedures significantly alter food intake, digestion, and nutrient absorption. Recent international studies emphasize that continuous nutritional monitoring helps maintain weight loss,

prevent weight regain, and reduce postoperative complications. A 2025 prospective observational study following bariatric patients for 10 years found that long-term nutritional follow-up was critical for detecting deficiencies in iron, folic acid, and vitamin B12, which increased significantly over time after surgery. The authors concluded that lifelong dietary assessment and micronutrient monitoring are necessary to ensure safe postoperative outcomes and maintain metabolic health after bariatric surgery(Humięcka; Sawicka; Kędzierska; Binda; Jaworski; Jaworski; Jankowski,2025).

Recent evidence also highlights that dietary follow-up should include structured nutritional counseling, staged dietary progression, and adherence monitoring. A 2025 study published in Scientific Reports reported that many patients experience significant changes in nutrient intake during the first year after bariatric surgery, particularly reductions in protein, iron, calcium, and vitamin B12 intake. Researchers emphasized that regular follow-up visits with dietitians improve dietary adherence and help patients transition safely through postoperative nutritional stages from liquids to pureed foods and eventually solid foods(Li; Shan; Kang;Chu;Chen; Sun & Deng,2025).

Furthermore, systematic reviews published in 2025 demonstrate that inadequate postoperative follow-up is strongly associated with severe micronutrient deficiencies and poor long-term outcomes. A rapid systematic review of case reports found that many nutritional complications occurring years after bariatric surgery were linked to insufficient dietary counseling, poor adherence to supplementation, and lack of regular medical monitoring. The review stressed that lifelong follow-up involving bariatric specialists, dietitians, and primary healthcare providers is essential to prevent complications such as anemia, osteoporosis, neurological disorders, and protein malnutrition(Haughton ; Gentry ; Parretti (2025).

Recent 2026 evidence further supports the importance of rigorous postoperative follow-up programs. A study published in MDPI Obesities showed that patients who participated in regular nutritional and metabolic follow-up achieved better micronutrient status, improved metabolic outcomes, and lower rates of postoperative complications compared with patients who had inconsistent follow-up care. Researchers concluded that long-term dietary follow-up after bariatric surgery should include routine laboratory testing, individualized nutritional counseling, protein intake monitoring, hydration assessment, and lifelong vitamin and mineral supplementation(Agosta; Sofia; Sofia; Latteri; Conti; Bellissimo; Mazzone; La Greca; Latteri,2025).

Analysis of the results comparing weight loss between the two systems, adherence rates, post-surgery outcomes, and weight improvement:

Recent studies comparing low-carbohydrate diets with balanced diets in patients with obesity demonstrate that both dietary approaches can achieve significant long-term weight loss when adherence is maintained. Evidence from randomized controlled trials and systematic reviews published in 2025 indicates that low-carbohydrate diets may produce greater early reductions in body weight and visceral fat; however, the long-term differences between the two dietary patterns become less pronounced over time. Researchers concluded that sustained caloric control and behavioral consistency are more important predictors of successful obesity treatment than macronutrient composition alone. A 2025 systematic review and meta-analysis published in International Journal of Obesity reported that low-carbohydrate dietary interventions significantly improved body weight and metabolic outcomes in obese patients, particularly when long-term adherence was achieved(Zheng; Gao; Ruan; Chen; Pan; Wang; Zhao; Yu; Li & Zhai ,2025)

Analysis of adherence rates showed that patients with obesity who participated in structured nutritional follow-up programs achieved more sustainable weight reduction and lower rates of weight regain. Long-term follow-up studies after sleeve gastrectomy published in 2025 demonstrated that adherence to dietary recommendations and regular postoperative monitoring were strongly associated with improved weight main tenance and better quality of life. In contrast, poor adherence to dietary guidance and missed follow-up visits were linked to suboptimal long-term outcomes and increased risk of postoperative complications. A recent study published in Obesity Surgery emphasized that continuous postoperative support and nutritional counseling significantly improved long-term adherence among bariatric patients(Dowgiałło-Gornowicz; Wityk & Lech ,2025).

Postoperative results after bariatric surgery also revealed substantial improvements in body weight and obesity-related metabolic disorders among patients who adhered to nutritional follow-up and staged dietary progression. Real-world observational studies published in 2025 showed that bariatric surgery produced sustained reductions in total body weight and significant improvements in diabetes control, cardiovascular risk factors, and overall health status. A large registry-based study published in PubMed – ANZ Journal of Surgery found that metabolic bariatric surgery resulted in durable long-term weight reduction and marked health improvements in obese patients, particularly when combined with long-term dietary monitoring and multidisciplinary postoperative care(Brown ; Brown ; Holland ; Campbell ; Cottrell ; Ahern ; Reilly ; Garduce ; Wetter ; Hamdorf ; Talbot ; Baker ; MacCormick ; Caterson ,2025).

Furthermore, recent postoperative nutritional studies indicate that patients who followed staged nutritional protocols after bariatric surgery (liquids → pureed foods → solid foods) achieved better postoperative weight outcomes and fewer nutritional complications. A 2025 observational cohort study published in Scientific Reports demonstrated that continuous dietary follow-up improved nutrient intake quality, reduced micronutrient deficiencies, and supported sustained postoperative weight improvement among obese patients(Li; Shan; Kang;Chu;Chen; Sun & Deng,2025).

Discuss and interpret the findings regarding:
Why might one diet be more successful than another for obese patients?

Recent evidence suggests that one dietary approach may be more effective than another in patients with obesity because obesity is a heterogeneous and multifactorial disease influenced by metabolic, hormonal, behavioral, psychological, and genetic factors. Studies published between 2024 and 2026 indicate that some patients respond more favorably to low-carbohydrate diets due to improved satiety, appetite suppression, reduced insulin

secretion, and enhanced fat oxidation. In contrast, other patients achieve better outcomes with balanced diets because these dietary patterns are generally easier to sustain over long periods and provide greater dietary flexibility. A recent review published in International Journal of Obesity concluded that individualized dietary strategies tailored to patient preferences, metabolic status, and lifestyle characteristics are more effective for long-term obesity management than generalized dietary recommendations(Zheng; Gao; Ruan; Chen; Pan; Wang; Zhao; Yu; Li &Zhai ,2025).

Behavioral and psychological factors also help explain why certain diets succeed in some obese patients but fail in others. Research has shown that adherence is strongly influenced by motivation, emotional eating patterns, stress, depression, social support, and behavioral counseling. Patients who receive regular nutritional education and structured behavioral interventions are more likely to maintain dietary adherence and achieve sustainable weight loss. A 2025 clinical study published in Obesity Surgery found that continuous dietary counseling and long-term follow-up significantly improved adherence rates and reduced weight regain among patients with obesity. Researchers emphasized that the effectiveness of a dietary intervention depends not only on nutrient composition but also on the patient's ability to maintain lifestyle modifications over time(Dowgiałło-Gornowicz; Wityk & Lech ,2025).

1- Inter-individual metabolic variability as a key determinant of dietary response:

Recent evidence indicates that variability in metabolic characteristics among individuals with obesity is one of the main reasons why dietary interventions produce different outcomes. Factors such as insulin sensitivity, genetic polymorphisms, and differences in energy metabolism contribute to heterogeneous responses to identical dietary regimens. Standardized "one-size-fits-all" dietary approaches often fail to account for this variability, leading to inconsistent weight loss and metabolic improvements. In contrast, personalized nutrition strategies that consider metabolic phenotypes have shown improved glycemic and weight-related outcomes by tailoring macronutrient distribution and caloric intake to individual needs(Shamanna ; Joshi ; Thajudeen; Shah; Poon; Mohamed; Mohammed,2024).

2- Role of gut microbiota in differential response to diets:

Another important explanation for variability in diet success among obese patients is the gut microbiota composition. Dietary patterns can significantly modify microbial diversity and metabolic activity, which in turn influence energy harvest, inflammation, and insulin sensitivity. Individuals with different microbial profiles may therefore respond differently to the same diet; for example, some may show greater improvement with high-fiber or Mediterranean-type diets due to favorable microbiome modulation, while others respond better to low-carbohydrate interventions. This supports the concept that gut microbiota is a central mediator linking diet and obesity outcomes(Lou;Li;Luo;Lei;Liu;Liu; Gao; Xu; Liu,2024).

3- Genetic predisposition and nutrigenetic effects:

Genetic variation also plays a crucial role in explaining why some diets are more effective than others. Single nucleotide polymorphisms (SNPs) in genes related to lipid metabolism, appetite regulation, and insulin signaling can alter nutrient utilization and fat storage. For instance, differences in genes such as FTO or PPARG may influence susceptibility to weight gain or responsiveness to low-fat versus low-carbohydrate diets. This supports the growing field of nutrigenetics, which suggests that dietary recommendations should be aligned with individual genetic profiles to optimize metabolic outcomes(Duc;Di Khanh; Khoa; Chi & Huyen ,2026).

4. Implications for personalized nutrition in obesity management

Overall, current evidence supports a shift away from universal dietary prescriptions toward personalized nutrition approaches that integrate metabolic, genetic, microbiome, and behavioral factors. Such individualized strategies may enhance weight loss, improve glycemic control, and reduce the risk of weight regain by aligning dietary interventions with patient-specific biological and lifestyle characteristics. This paradigm represents a promising direction for improving long-term obesity management outcomes(Roman ;Campos-Medina; Leal-Mercado,2024).

5-Dietary patterns interfere with gut microbiota to combat obesity

- Recent evidence suggests that dietary patterns play a fundamental role in modulating gut microbiota composition and function, thereby influencing obesity development and metabolic health. The gut microbiota contributes to energy homeostasis, nutrient metabolism, inflammation, and fat storage, all of which are closely associated with obesity pathogenesis. Unhealthy dietary patterns, particularly Western-style diets rich in saturated fats, refined carbohydrates, and low fiber content, are associated with reduced microbial diversity and increased abundance of pro-inflammatory bacteria. In contrast, healthy dietary patterns rich in dietary fiber, polyphenols, fruits, vegetables, and whole grains promote the growth of beneficial bacteria and enhance the production of short-chain fatty acids (SCFAs), which improve gut barrier integrity, insulin sensitivity, and appetite regulation. These mechanisms may explain why some dietary interventions are more effective than others in reducing body weight and metabolic complications among obese individuals(Lou;Li;Luo;Lei;Liu;Liu; Gao; Xu; Liu,2024).
- The Mediterranean diet has emerged as one of the most effective dietary patterns for improving gut microbiota composition and combating obesity. This dietary model is characterized by high intake of vegetables, fruits, legumes, olive oil, nuts, and fish, all of which provide bioactive compounds that positively influence microbial diversity. Recent systematic reviews demonstrated that adherence to the Mediterranean diet increases the abundance of beneficial bacterial genera such as Faecalibacterium, Roseburia, and Bifidobacterium, which are associated with anti-inflammatory effects and improved metabolic health. Moreover, Mediterranean dietary adherence has been

linked to reduced systemic inflammation, enhanced insulin sensitivity, and lower visceral fat accumulation, partly through gut microbiota-derived metabolites. These findings support the hypothesis that modulation of the gut microbiome is an important mechanism underlying the anti-obesity effects of healthy dietary patterns(Khavandegar; Heidarzadeh; Angoorani; Hasani-Ranjbar; Ejtahed; Larijani & Qorbani(2024).

- Overall, the interaction between dietary patterns and gut microbiota represents a promising therapeutic target in obesity management. Personalized nutritional interventions based on individual microbial composition may improve treatment response, enhance long-term adherence, and reduce obesity-related metabolic complications. Future research should focus on identifying microbiota-based biomarkers that can predict dietary responsiveness and support the development of precision nutrition strategies for obesity treatment(Cani & Van Hul ,2025).

Genetic predisposition and nutrigenetic effects:

- Genetic predisposition is increasingly recognized as a major factor contributing to obesity susceptibility and variability in response to dietary interventions. Obesity is a multifactorial disorder influenced by interactions between environmental exposures and numerous genetic variants that regulate appetite, energy expenditure, lipid metabolism, and insulin sensitivity. Recent genomic studies identified several obesity-associated genes, including FTO, MC4R, PPARG, and ADIPOQ, which may alter metabolic responses to different macronutrient compositions. Consequently, individuals carrying specific genetic variants may respond more favorably to certain dietary strategies, such as low-carbohydrate or low-fat diets, while others may experience limited benefits from the same intervention. This genetic heterogeneity may partially explain why no single dietary approach is universally effective for all patients with obesity(Gkouskou;Grammatikopoulou; Lazou;Vasilogiannakopoulou;Sanoudou & Eliopoulos,2024).

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- The emerging field of nutrigenetics has provided important insights into how gene–nutrient interactions influence obesity management outcomes. Nutrigenetics examines how inherited genetic differences modify physiological responses to nutrients and dietary patterns. Recent evidence suggests that personalized dietary interventions based on genetic profiling may improve weight reduction, glycemic control, and long-term adherence compared with conventional generalized dietary recommendations. For example, variants in genes related to lipid metabolism and insulin signaling may determine whether an individual achieves greater metabolic improvement with reduced carbohydrate intake or lower dietary fat consumption. These findings support the concept of precision nutrition, in which dietary recommendations are tailored according to individual genetic characteristics to optimize obesity treatment outcomes(Singar; Nagpal; Arjmandi; Akhavan,2024).
- Furthermore, studies have demonstrated that genetic polymorphisms may influence eating behaviors, satiety regulation, and food preferences, thereby indirectly affecting dietary adherence and weight-loss success. Individuals with obesity-related genetic variants may exhibit altered hunger signaling, increased preference for energy-dense foods, or impaired satiety responses, which can increase the risk of overeating and weight regain. Personalized nutrition approaches that consider behavioral and genetic predispositions may therefore improve adherence to dietary interventions and support sustainable lifestyle modification. This may explain why some individuals maintain long-term weight loss successfully, whereas others experience early relapse despite following similar dietary regimens(arrea; Annunziata; Bordoni; Muscogiuri; Colao & Silvia ,2020).
- Recent reviews also highlighted the importance of integrating genomics with other biological factors, including gut microbiota composition, metabolomics, and lifestyle behaviors, to achieve more effective obesity management. Modern precision nutrition models emphasize that obesity treatment should not rely solely on calorie restriction but rather on understanding the complex interactions between genes, metabolism, dietary patterns, and environmental factors. Such integrated approaches may improve prediction of dietary responsiveness and reduce inter-individual variability in obesity treatment outcomes. Nevertheless, although nutrigenetic strategies show promising results, further large-scale clinical trials are still needed before routine implementation in clinical practice can be fully established(Farzand; Rohin; Awan; Ahmad; Akram; Saleem; Imran,2025).

The role of behavior and adherence in obese patients:

- Behavioral factors and long-term adherence play a central role in determining the success of obesity treatment. Although many dietary interventions initially produce significant weight loss, maintaining these outcomes over time remains challenging for many patients with obesity. Recent evidence suggests that adherence to dietary recommendations, physical activity, and lifestyle modifications is often more important than the specific dietary composition itself. Patients who consistently follow calorie-controlled eating patterns and maintain healthy behavioral habits generally achieve better long-term weight management outcomes regardless of whether they follow low-carbohydrate, low-fat, or Mediterranean-style diets. This may explain why differences between dietary approaches frequently diminish after prolonged follow-up periods(Barber; Kabisch; Pfeiffer; Weickert,2025).
- Psychological and behavioral characteristics are also major determinants of dietary adherence in obese individuals. Emotional eating, stress, anxiety, depression, binge-eating tendencies, and low motivation have all been associated with poor adherence to dietary

interventions and increased risk of weight regain. Recent systematic reviews demonstrated that patients experiencing psychological distress are more likely to consume high-calorie foods, engage in unhealthy eating behaviors, and discontinue structured weight-loss programs prematurely. Consequently, behavioral and psychological support strategies are increasingly recognized as essential components of effective obesity management(Althumiri; A Bindhim; Al-Rayes,2024).

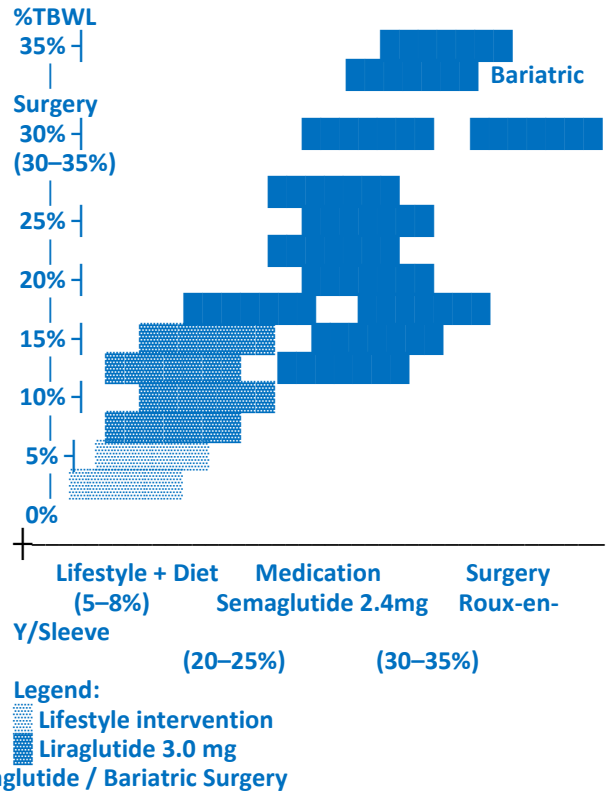
- Behavioral science interventions have shown promising effects in improving adherence and promoting sustainable weight loss among obese patients. Strategies such as self-monitoring, motivational interviewing, goal setting, behavioral counseling, digital reminders, financial incentives, and social support systems have been associated with improved physical activity adherence and healthier eating behaviors. These interventions help patients develop long-term lifestyle habits rather than relying solely on temporary dietary restriction. Recent randomized controlled trials highlighted that combining nutritional therapy with behavioral modification techniques significantly improves weight-loss maintenance and treatment adherence(Corrêa ; Tabak ,2024).
- In addition, several barriers may interfere with long-term adherence to obesity interventions. Common barriers include lack of social support, limited time, financial constraints, food cravings, emotional stress, unrealistic expectations, and difficulty maintaining lifestyle changes in daily life. Conversely, factors such as family support, regular follow-up with healthcare professionals, personalized counseling, and achievable goal-setting may facilitate adherence and improve treatment outcomes. These findings emphasize that obesity management should not focus solely on caloric restriction but also address behavioral, psychological, and environmental factors influencing patient compliance(Farzand; Rohin; Awan; Ahmad; Akram; Saleem; Imran,2025).
- Overall, current evidence supports the view that successful obesity treatment depends largely on sustainable behavioral change and long-term adherence rather than the superiority of a single dietary approach. Individualized interventions that integrate nutritional guidance with psychological and behavioral support appear to provide the most effective strategy for achieving durable weight loss and preventing weight regain in obese patients((Barber; Kabisch; Pfeiffer; Weickert,2025).

Confirmation that:

- **There is no one-size-fits-all approach.**
- **Nutritional intervention after surgery is a crucial factor for success.**

Comparative Weight Loss (%) in Obese Patients (1 Year)

Mean Percentage Total Body Weight Loss (%TBWL) after 52-68 weeks



(%TBWL)

(*Case Study*) :

A comparison showing the effect of introducing a behavioral modification factor on an individual's adherence to a diet:

Case study: The impact of behavioral intervention on diet adherence

• Case: M.A., 35 years old, overweight (Class I obesity) and with a history of unsuccessful dieting. • Problem before psychological intervention: Emotional eating, inability to resist urges, viewing dieting as punishment. • Intervention: Balanced diet plan + behavior modification sessions (identifying eating triggers, mindful eating techniques, stress management).

1. Comparison table: Before and after psychological intervention.

Comparative indicator behavior modification + diet). after introducing the psychological factor indicator before introducing the psychological factor (traditional diet)

Diet type : Severe deprivation / Very low calories A balanced and customized (psychological) system.

Adherence fluctuating (2 days of commitment + 5 days of excess) Long-term commitment) (lifestyle change
Psychological impact: tension, emotional hunger, self-criticism; Conversely, calmness, enjoyment of food, nutritional awareness.
Responding to eating Cravings urges involves giving in to cravings and the ability to postpone and evaluate (Habit Formation).
Results (6 months) Loss of 2 kg (then regained 4 kg) Loss of 10-12 kg (weight stability)
2. Chart: Diet adherence (before/after):
This graph illustrates how commitment and psychological awareness increase over time when the behavioral aspect is incorporated, compared to the rapid decline associated with traditional dieting.
Level of commitment (100%)
Level of Commitment to Weight-Loss Programs
Key Interpretation:
• Commitment increases significantly after psychological intervention.
• Traditional diet adherence declines gradually over time.
• Behavioral support improves long-term compliance and sustainability.

Example Data Points (for plotting):
Time (months) Post-Bariatric Surgery (%)

Post-Bariatric Surgery (%)	Balanced Diet (%)	Low-Carb Diet (%)	Time (months)
0	0	0	0
3	10	7	20
6	15	10	25
12	18	13	28
18	20	14	29
12	22	15	30

Suggested Chart Type:

Line chart with three lines representing each group.
Include legends for clarity.
Optionally, add annotations about nutritional interventions in the post-bariatric group.

Suggested Chart Type:

Line chart with three lines representing each group.
Include legends for clarity.
Optionally, add annotations about nutritional interventions in the post-bariatric group
3-Case Analysis:
• Phase 1-3 months (Adjustment):
-The study showed that behavioral interventions (such as learning mindful eating techniques) increase adherence, leading to significant and gradual weight loss compared to traditional diets.
• Phase 3-12 months (Sustainability):
-The results showed that individuals who received behavioral and psychological support were significantly more successful at maintaining their weight loss (weight management) than those who only followed a diet.
• The key psychological factor:
-The ability to transform "food deprivation" into "consciously choosing healthy food.
Conclusion: Incorporating the behavioral aspect doesn't change the calories consumed, but rather the mindset surrounding calories, thus ensuring the sustainability of the results.
Recommendations:
- Choosing a diet based on individual needs.
- Medical follow-up is essential after surgery.
- Focus on sustainability, not speed.

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