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Effects of oral nutritional supplementation in a case-management model on body composition changes in patients after bariatric surgery.

*Juan Cheng*and Yu Guo*

Department of Gastrointestinal Surgery, Jiangsu Province (Suqian Hospital), Suqian, Jiangsu, China.

Keywords: obesity; bariatric surgery; oral nutritional supplementation; case management model; body composition; self-management.

Abstract. This study explores the effects of oral nutritional supplementation in a case-management model on body composition alterations in patients after bariatric surgery. One hundred and twenty obese patients admitted to the Jiangsu Province Suqian Hospital from January 2024 to March 2025 who underwent bariatric surgery were included. Patients were divided into an observation group and a control group. The control group adopted routine nursing measures. Based on routine nursing measures, the observation group adopted an individualized nutritional supplement intervention according to the ideal body weight and the principle of limiting energy intake. One and three months after surgery, compared with the control group, the improvements of body fat percentage, free fat mass (FFM), body mass index (BMI), body weight, skeletal muscle mass, and excess weight loss rate in the observation group were more significant. The albumin, hemoglobin, and total protein levels were higher; emotional eating, external eating, restrained eating, and the Bariatric Surgery Self-management Questionnaire (BSSQ) scores were significantly improved. The scores of physical function, social function, physical pain, emotional function, general health, mental health, physical role, and vitality were higher. The total incidence of postoperative complications was lower, while the total nursing satisfaction rate of patients was higher. To sum up, oral nutritional supplementation in the case-management model can improve body composition, promote nutritional status, reduce the incidence of complications, promote postoperative self-management ability, and enhance the quality of life and nursing satisfaction in patients after bariatric surgery.

Corresponding author: Juan Cheng. Department of Gastrointestinal Surgery, Jiangsu Province (Suqian Hospital), Suqian, 223800 Jiangsu, China. E-mail: syrchengj1984@163.com

Efecto de la suplementación nutricional oral en un modelo de cambios en la composición corporal en pacientes después de cirugía bariátrica.

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Palabras clave: obesidad; cirugía bar iátrica; suplementación nutricional oral; modelo de manejo de casos; composición corporal; autogestión.

Resumen. Este estudio tiene como objetivo explorar los efectos de la suplementación nutricional oral en un modelo de manejo de casos sobre las alteraciones de la composición corporal en pacientes después de cirugía bariátrica. Se incluyeron 120 pacientes obesos ingresados en el Hospital de la provincia de Jiangsu Suqian desde enero de 2024 hasta marzo de 2025 que se sometieron a cirugía bariátrica. Los pacientes se dividieron en un grupo de observación y un grupo control. Al grupo control se le aplicaron medidas de enfermería de rutina. Con base a las medidas de rutina de enfermería, al grupo de observación se le aplicó una intervención individualizada de suplementos nutricionales de acuerdo con el peso corporal ideal combinado con el principio de limitar la ingesta energética. Uno y tres meses después de la operación, en comparación con el grupo control, las mejorías en porcentaje de grasa corporal, masa libre de grasa, índice de masa corporal , peso corporal, masa muscular esquelética y tasa de pérdida de exceso de peso en el grupo de observación fueron más significativas. Los niveles de albúmina, hemoglobina y proteína total fueron mayores. El dolor físico, la función emocional, el estado general de salud, la salud mental, el papel físico y la vitalidad mejoraron; la incidencia total de complicaciones postoperatorias, los puntajes del Cuestionario de Autogestión de la Cirugía Bariátrica (BSSQ) y la tasa de satisfacción total de enfermería de los pacientes fueron mayores. En resumen, la suplementación nutricional oral en el modelo de manejo de casos puede mejorar la composición corporal, promover el estado nutricional, reducir la incidencia de complicaciones, promover la capacidad de automanejo postoperatoria, junto con una mejoría en la calidad de vida y la satisfacción de la enfermería en pacientes de cirugía bariátrica.

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INTRODUCTION

Obesity is recognized as a disease by the World Health Organization, and according to statistics, 38% of the global population was overweight and obese in 2020, and this figure is expected to rise to 51% by 2035 [1]. According to the Dietary Guidelines for Chinese Residents (2022), the number of obese people in China ranks first in the world [2]. At present, the treatment of obesity is mainly based on behavior, diet, exercise, drugs and surgery [3]. Compared with other treatments, bariatric surgery can reduce weight more quickly, effectively and sustainably in patients with morbid obesity or obesity complications by limiting food intake along with reducing nutrient absorption, and has become the most effective treatment for patients with moderate and severe obesity [4]. Studies

have shown that postoperative changes in the digestive tract structure can affect nutrient absorption to varying degrees, thus increasing the risk of malnutrition and associated complications, and eventually leading to malnutrition [5]. Malnutrition is a common clinical problem after bariatric surgery [6]. Therefore, nutrition management is essential for patients after bariatric surgery.

Body composition refers to the content of various components in the body, containing three categories: fat mass, muscle mass and bone mineral salt content [7]. Muscle mass's physiological and metabolic function differs from that of fat mass, and muscle mass is the main metabolically active component of the human body [8]. Muscle mass loss may affect the body mass loss rate after bariatric surgery by reducing resting energy expenditure [9]. Loss of weight includes not only the loss of fat mass, but also the loss of muscle mass [10]. Foreign studies have found that the loss of muscle tissue after bariatric surgery will have a negative impact on the long-term effect of bariatric surgery, human health, and quality of life, and can endanger the life of patients in severe cases [11]. The main components of human muscle tissue include lean body mass (LBM), fat-free mass (FFM), along with skeletal muscle mass (SMM) [12]. The loss of FFM mainly occurs within three months after bariatric surgery, when patients are prone to malnutrition [13]. At present, domestic and foreign studies have shown that in order to avoid the occurrence of postoperative malnutrition and reduce the loss of FFM, patients are usually given at least 60 g/d of protein-rich low-carbohydrate oral nutritional supplement after surgery, and whey protein formula is the preferred formula [14]. However, most patients with bariatric surgery have destructive eating behaviors before surgery, lack of health awareness and poor self-control after surgery, and need different nutritional components and amounts due to individual differences [15]. Therefore, individualized oral nutritional supplementation for patients after bariatric surgery may effectively improve the clinical outcome of patients, decrease the loss of muscle tissue after bariatric surgery, improve the effect of bariatric surgery along with improving patients' dietary behavior compliance, so as to better manage weight loss for patients [16].

Case management belongs to a health care system for a disease that contains assessment, planning, service, coordination, and monitoring to meet the multiple health requirements of individuals and promote cost-effective and high-quality services [17]. The case-management model has been successively applied to burns, acquired immune deficiency syndrome, tuberculosis, cancer, mental illness and other complicated diseases, as well as chronic diseases such as diabetes, hypertension and other long-term care systems [18-20]. In addition, the case management model has achieved specific results in nutritional supplementation, emphasizing the importance of personalized management, and is currently used in all kinds of population interventions with extensive adaptability [21]. However, case management of oral nutritional supplementation in patients with bariatric surgery is rare.

Based on the case-management model, this study constructed an oral nutritional supplement program for patients after bariatric surgery to explore the influence of this program on the related indexes of body composition of patients after bariatric surgery, in order to provide a theoretical basis and practical guidance for nutritional management of patients after bariatric surgery.

PATIENTS AND METHODS

General data

One hundred and twenty obese patients admitted to our hospital from January 2024 to March 2025 who underwent bariatric surgery were selected as study subjects. Inclusion criteria: (1) Age ranged from 18-65 years old; (2) In line with the surgical indications of the "Expert Consensus on nutrition and multidisciplinary management of bariatric

surgery"; (3) Patients undergoing their first bariatric surgery; (4) Normal communication skills, skilled use of mobile APP's. Exclusion criteria: (1) Complicated with serious heart, lung, kidney and other diseases; (2) With mental illness; (3) Patients undergoing corrective surgery; (4) Pregnant or lactating women; (5) Incomplete clinical data collection. Patients were divided into an **observation group** and a **control group** following the time order of operation, with 60 patients in each group. No difference was seen in general data between the two groups ($p>0.05$, Table 1), reflecting comparability. This study was approved by the ethical committee of the Jiangsu Province Suqian Hospital and followed the guidelines of the Declaration of Helsinki of 1975, revised in 2013. Each patient has signed the informed consent.

METHODS

The **control group** adopted routine nursing measures. Before bariatric surgery, the routine preparation plan was conducted. Postoperative education was guided according to the phased diet principle: drinking water (1-3 days after surgery) →blandliquid-diet (1-2 weeks after surgery) → fluid diet (3-4 weeks after surgery) → semi-fluid diet (5-6 weeks after surgery) → soft food (7-12 weeks after surgery) → low-calorie balanced diet (12 weeks after surgery). The daily water intake was at least 1500-2000 mL, and the patients were instructed to take special vitamins for weight loss, orally, after surgery. Patients began taking an oral protein powder for weight loss on day 8 and consumed at least 60 g of protein daily. The weight loss education manual was distributed, and the case manager was responsible for managing the weight loss WeChat group and answering the patients' questions. Patients were urged to eat as required after discharge and informed to go to the hospital for a follow-up visit one and three months after surgery.

Based on routine nursing measures, the **observation group** adopted an individualized nutritional supplement intervention according to the ideal body weight and the principle of limiting energy intake.

(1) Setting up a research team. Nutrition specialist nurse Juan Cheng and nutrition physician Liping Su developed an individualized oral nutrition supplement program for patients after bariatric surgery, and chief physician Guodong Liu made adjustments. Yu Guo taught the patients to use the "Menthol Health" nutritionist app and record their dietary intake for 24 hours. The nutrition specialist nurses analyzed and sorted the collected data every week and dynam-

Table 1. General data of patients in the two groups.

Items		Control group (n=60)	Observation group (n=60)	t/χ^2	p
Gender	Male	20 33.33)	18 (30.00)	0.154	0.694
	Female	40 66.67)	42 (70.00)		
Age (years)		31.26±4.21*	31.31±4.26	0.064	0.948
Marital status	Married	39 65.00)	38 (63.33)	0.036	0.190
	Unmarried	21 35.00)	22 (36.67)		
Degree of education	Junior high school and below	10 (16.67)	11 (18.34)	0.068	0.966
	Senior high school	24 (40.00)	23 (38.33)		
	University and above	26 (43.33)	26 (43.33)		

Data is expressed as n (%); or *mean ± SD.

ically adjusted the intake plan of nutritional preparations. Menglin Zhang was responsible for the analysis and detection of body composition one and three months after bariatric surgery, and used the questionnaire to issue the Dutch Eating Behavior Questionnaire (DEBQ) and the Bariatric Surgery Self-management Questionnaire (BSSQ) to understand the patients' dietary compliance and self-management ability. Lidan Zhao was responsible for the statistics, and the statistical data were entered and checked jointly by the two of them. The statistician did not participate in the design and implementation of the program.

(2) Oral nutritional supplement program after bariatric surgery. On the day of admission, the case manager measured the patient's height, weight, circumference and body composition, conducted preoperative diet education according to the measured results, and established the case file. One to two days after surgery, the nutrition specialist nurse instructed the patient to drink a small amount of water several times, and gave the patient warm water 20-30 mL/time, 3-5 times, once/h, and instructed the patient to drink slowly, 500 mL of water on the day and 1000 mL of water on the second day. Three to six days after surgery, the patient was given a bland liquid diet + whey protein powder (45 g/d). The patient was guided to drink 1500 mL of water, and the patient's energy intake was 600 kcal/d. One to two weeks after surgery, the patient was given a fluid diet + whey protein powder (60 g/d), and the patient's energy intake was 10 kcal (kg·d). Three to four weeks after surgery, the patient was given a semi-fluid diet + whey protein powder (60 g/d), and the patient's energy intake was 15 kcal (kg·d). Two to three months after surgery, the patient was given soft food + whey protein powder (60 g/d), and the patient's energy intake was 20 kcal (kg·d). Among them, the dietary requirements for one week to three months after surgery were 40% to 45% carbohydrates, 20% to 30% fat, 25% to 30% protein + weight loss special complex vitamins, and daily drinking water ≥ 2000 mL.

Control Group: Postoperative diet progression protocol

In this study, all patients followed a structured diet advancement protocol after bariatric surgery, beginning with clear fluids and gradually progressing to a soft diet. The dietary phases were as follows:

- Days 1–3 post-surgery: Clear fluids only
- Weeks 1–2: Bland liquid diet
- Weeks 3–4: Full fluid diet
- Weeks 5–6: Semi-fluid/pureed diet
- Weeks 7–12: Soft food diet
- After week 12: Transition to a low-calorie, balanced solid diet

This extended progression was based on institutional protocol, aimed at reducing the risk of early gastrointestinal intolerance and complications. Protein supplementation (minimum 60 g/day) was initiated during the fluid phase and continued throughout recovery. Patients were counselled to follow prescribed meal volumes, texture guidelines, and hydration targets (≥2000 mL/day).

All patients undergoing bariatric surgery were provided with standardized preoperative dietary guidance upon admission to the hospital. Specifically, patients were instructed to follow a low-calorie, high-protein, low-carbohydrate liquid diet for seven to ten days before surgery. This preoperative diet was designed to reduce liver volume, decrease visceral adiposity, and enhance surgical visibility and safety. The prescribed regimen typically included 800–1000 kcal/day, with at least 60–80 g of protein, and emphasized adequate fluid intake (≥1500 mL/day). Acceptable liquids included clear broths, low-fat dairy, protein shakes, and sugar-free beverages. Patients were advised to avoid solid foods, sugary drinks, carbonated beverages, and high-fat items. The case

management nurse conducted a brief in-hospital orientation session to reinforce dietary compliance, and adherence was monitored through verbal recall and written logs during preoperative assessments. Patients who demonstrated non-adherence were counselled and re-evaluated before surgical clearance.

In the present study, the phrase "dynamically adjust the intake plan of nutritional preparations" refers to the individualized modification of oral nutritional supplement (ONS) prescriptions based on the patients' daily energy and protein intake, as recorded through a dietary tracking app (Menthol Nutritionist). These adjustments were not related to food preparation, culinary menu design, or traditional meal planning, but rather to the quantitative regulation of supplement dosage—particularly whey protein powder—to ensure that nutritional intake aligned with the patient's postoperative recovery phase and ideal body weight. Specifically, adjustments targeted a protein intake of at least 60 g/day and an energy intake ranging from 10 to 20 kcal/kg/day, depending on the time elapsed since surgery. The data collected were reviewed weekly by the nutrition specialist nurse and supervising nutrition physician, who modified the amount and timing of ONS accordingly. While this nurse-led protocol provided a structured method for managing macronutrient intake, we acknowledge that it does not replace the comprehensive services of a registered dietitian formally trained to develop evidence-based individualized nutrition care plans. The absence of dietitian involvement represents a limitation and underscores the need for future studies to incorporate certified clinical dietitians as core members of the bariatric care team.

Observation indicators

(1) Patients were asked to weigh themselves on an empty stomach in the morning, wearing light clothes and bare feet. The test instrument was measured by an HCS-200RT weight scale, with kg as the unit of measurement, and the error was not more than 0.01 kg. A column height gauge measured the height; the waist and hip circumference were measured by a soft tape measure with cm as the unit of measurement, and the error should not exceed 0.01 cm. The Inbody 3.0 body composition analyzer was used to measure body composition. Body weight, BMI, FFM, body fat percentage (%), skeletal muscle mass and excess weight loss rate were recorded after the test.

(2) Nutritional indicators, including hemoglobin, albumin, and total protein, were compared between the two groups.

(3) The total incidence of postoperative complications, including abdominal hemorrhage, gastric fistula, vomiting, as well as anastomotic stenosis, was compared between the two groups.

(4) DEBQ was used to assess the postoperative eating behavior of patients in the two groups [22]. DEBQ included three dimensions: emotional, external, and restrained eating. 1 point represented "never," and 5 points represented "always." The higher the score, the higher the level of corresponding eating behavior.

(5) The Bariatric Surgery Self-Management Questionnaire (BSSQ) is a validated instrument designed to evaluate self-management behaviors critical to postoperative recovery and long-term success following bariatric surgery. The BSSQ consists of 33 items divided into multiple domains, including:

1. Dietary behaviors (e.g., protein intake, hydration, meal timing)
2. Physical activity adherence
3. Medication and supplement compliance
4. Self-monitoring behaviors (e.g., weight, symptoms, food logs)
5. Emotional coping and support-seeking behaviors

Each item is scored on a 5-point Likert scale ranging from "Never" (1) to "Always" (5), with higher scores indicating better adherence to recommended self-management practices. The total score ranges from 33 to 165, and in our study, it was rescaled to a 0–99 scale for comparative purposes. The BSSQ was administered postoperatively to both groups at one and three months by trained study personnel. Patients in the observation group were counselled more intensively on these domains as part of the case-management model, which may have contributed to their significantly higher BSSQ scores.

(6) The quality of life was assessed using the Short-Form 36 (SF-36) score [24], which included eight dimensions (physical function, social function, physical pain, emotional function, general health, mental health, role physical, and vitality), with a score of 0-100 for each dimension. The quality of life was positively correlated with the score.

(7) During hospitalization, the nursing satisfaction questionnaire made by our hospital was used to evaluate nursing satisfaction of patients, with a full score of 100. According to the score, it could be divided into satisfaction (score ≥80 points), basic satisfaction (60 points ≤ score <80 points) and dissatisfaction (score <60 points). Nursing satisfaction = (number of satisfaction cases + number of basic satisfaction cases)/total cases ×100%.

Assessment of dietary and vitamin intake compliance

Actual dietary intake—including protein, energy, fluid, and vitamin supplement consumption—was monitored using the Menthol Nutritionist app, where patients in both groups were instructed to record their 24-hour food and supplement intake. Compliance was assessed weekly by the case management team, with guidance provided for underreporting or deviations from the instructed plan. However, quantitative intake was only analyzed in the observation group, where the app data were actively used to tailor ONS dosages. In the control group, while intake logs were encouraged and verbally reviewed during follow-ups, no structured method was used to quantify or verify adherence to the prescribed dietary or vitamin regimen. Laboratory markers such as hemoglobin, albumin, and total protein were used as indirect indicators of nutritional adequacy, but specific micronutrient levels (e.g., iron, B12, vitamin D) were not assessed.

Micronutrient supplementation protocol

All patients were routinely prescribed a standardized bariatric multivitamin complex starting from the first week after surgery to address the risk of postoperative micronutrient deficiencies. The formulation used contained at minimum:

- Iron (≥45 mg)
- Vitamin B12 (≥350–500 mcg)
- Folic acid (400–800 mcg)
- Calcium citrate (≥1200–1500 mg) with Vitamin D3 (≥3000 IU)
- Vitamin A (≥5000 IU), Vitamin E, and Zinc in bariatric-recommended dosages

This formulation followed the guidelines established for post-bariatric patients to prevent common deficiencies in iron, B12, folate, calcium, and fat-soluble vitamins. Patients were advised to take divided doses (e.g., twice daily) and were monitored for adherence during follow-up visits. The same vitamin regimen was provided to the control and observation groups to avoid bias introduced by unequal micronutrient support.

Oral nutritional supplement program after bariatric surgery

Personalization of ONS Based on Ideal Body Weight and Energy Restriction in the observation group, oral nutritional supplementation (ONS) was tailored using a sim-

plified protocol based on each patient's ideal body weight (IBW) and postoperative energy restriction targets. IBW was calculated using the standard formula:

- IBW (kg) = 22 × height² (m²)
- Daily energy intake goals were set according to the postoperative phase:
- Week 1–2: 10 kcal/kg IBW/day
- Week 3–4: 15 kcal/kg IBW/day
- Week 5–12: 20 kcal/kg IBW/day

Protein requirements were uniformly set at a minimum of 60 g/day, adjusted upward if tolerated, particularly for patients with higher baseline BMI or physical activity levels.

All patients in the observation group received the same brand of whey protein powder (a medical-grade, high-biological-value supplement), but dosages were individualized to help patients reach their energy and protein targets when food intake was inadequate. The protein powder contained approximately 25 g of protein and 150 kcal per serving, and was administered in divided doses (1–3 servings/day) based on intake gaps identified through dietary logs. No flavor or formula variations were used, and micronutrient content was not adjusted individually—this was standardized and supplemented through bariatric multivitamin capsules given to all patients.

Specification of whey protein supplement used

All patients in the observation group received the same commercially available whey protein supplement, a whey protein isolate powder containing approximately 25 g of protein, 2 g of carbohydrates, 1 g of fat, and 150 kcal per 30 g serving. The supplement was not fortified with vitamins or minerals, and therefore did not serve as a complete meal replacement. It was used exclusively to meet daily protein intake targets (minimum of 60 g/day) and routine bariatric multivitamin supplementation. Patients consumed 1–3 servings daily based on their estimated protein gap from dietary intake, calculated using ideal body weight and reported food logs.

Statistical analysis

SPSS 24.0 statistical software was adopted for data analysis. Measurement data were expressed as $\bar{x}\pm SD$, and t-test and ANOVA were adopted for comparison. Count data were expressed as [n (%)], and the χ^2 test was adopted for comparison. $p<0.05$ represented that the difference was statistically significant.

RESULTS

Body composition of patients in the two groups

At one and three months after surgery, the body fat percentage, FFM, BMI and body weight in both groups were lower than baseline ($p<0.05$), while the skeletal muscle mass and excess weight loss rate in both groups were higher than baseline ($p<0.05$). Meanwhile, relative to the control group, the improvements of the above body composition in the observation group were more significant ($p<0.05$), as displayed in Fig. 1.

Nutritional status of patients in the two groups

At 1 and 3 months after surgery, the body fat percentage, albumin, hemoglobin and total protein levels in both groups were higher than baseline ($p<0.05$). Meanwhile, relative to the control group, the levels of albumin, hemoglobin, and total protein in the observation group were higher ($p<0.05$, Fig. 2).

Incidence of postoperative complications in the two groups

Relative to the control group, the total incidence of postoperative complications in the observation group was lower ($p<0.05$, Table 2).

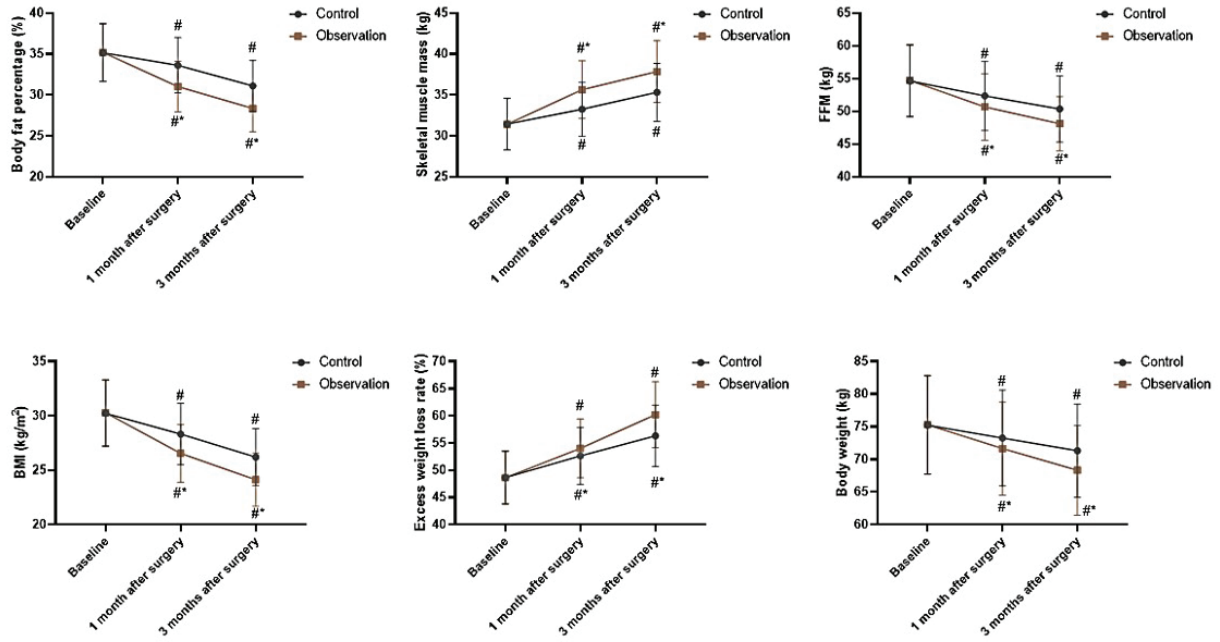

Fig. 1. Body composition of patients in the two groups. #p<0.05, vs baseline (ANOVA); *p<0.05, vs control group (t test).

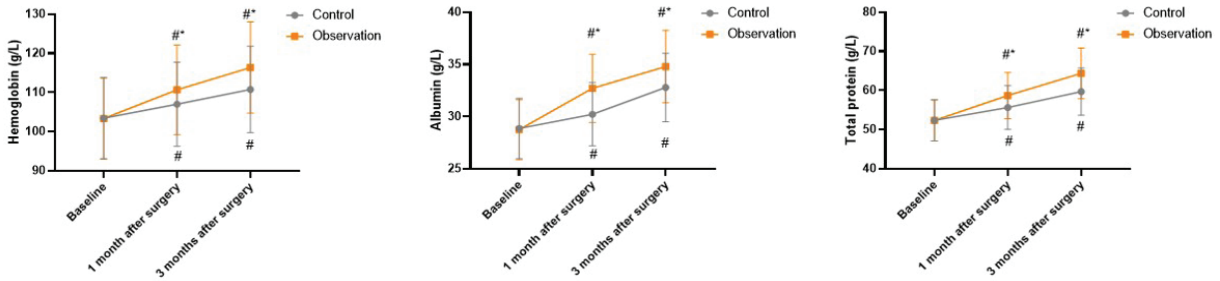

Fig. 2. Nutritional status of patients in the two groups. #p<0.05, vs baseline (ANOVA); *p<0.05, vs control group (t test).

Table 2. Incidence of postoperative complications in the two groups.

Groups	N	Abdominal hemorrhage	Gastric fistula	Vomiting	Anastomotic stenosis	Total incidence rate
Control group	60	3 (5.00)	2 (3.33)	3 (5.00)	3 (5.00)	11 (18.33)
Observation group	60	0 (0.00)	1 (1.67)	1 (1.67)	1 (1.67)	3 (5.01)
χ^2						5.175
p						0.022

Data is expressed as n (%).

Postoperative eating behavior of patients in the two groups

At 1 and 3 months after surgery, the scores of emotional eating and external eating in both groups were lower than baseline ($p<0.05$), while the score of restrained eating in both groups was higher than baseline ($p<0.05$). Meanwhile, relative to the control group, the improvements of the scores of emotional eating, external eating and restrained eating in the observation group were more significant ($p<0.05$), as displayed in Fig. 3.

Postoperative self-management behaviors of patients in the two groups

At 1 and 3 months after surgery, the BSSQ scores in both groups were higher than baseline ($p<0.05$), and relative to the control group, the BSSQ scores in the observation group were higher ($p<0.05$), as displayed in Fig. 4.

Quality of life in the two groups

At 1 and 3 months after surgery, the scores of physical function, social function, physical pain, emotional function, general health, mental health, role physical, and vitality in both groups were higher than baseline ($p<0.05$). Relative to the control group, the scores of physical function, social function, physical pain, emotional function, general health, mental health, role physical, and vitality in the observation group were higher ($p<0.05$), as displayed in Fig. 5.

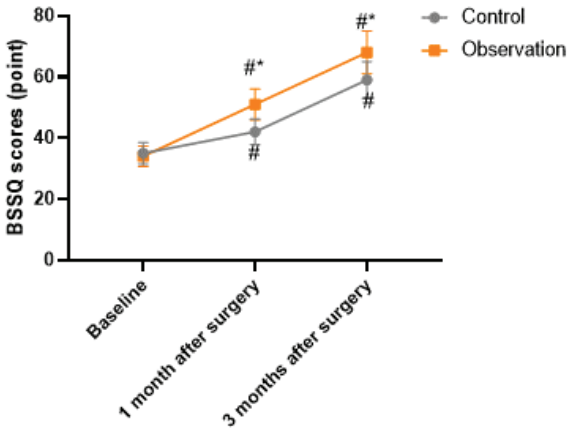

Fig. 4. Postoperative self-management behaviors of patients in two groups. #$p<0.05$, vs baseline (ANOVA); *$p<0.05$, vs control group (t test). #$p<0.05$, vs baseline; *$p<0.05$, vs control group.

Nursing satisfaction of patients the two groups

Relative to the control group, the total nursing satisfaction rate of patients in the observation group was higher ($p<0.05$, Table 3).

DISCUSSION

Obesity is a pathological condition in which fat accumulates excessively, usually caused by excessive nutrient intake [25]. Obesity is linked to an increased risk of hypertension, diabetes, lipid disorders, sleep disorders, coronary heart disease, and stroke [26]. Studies have shown that reducing weight

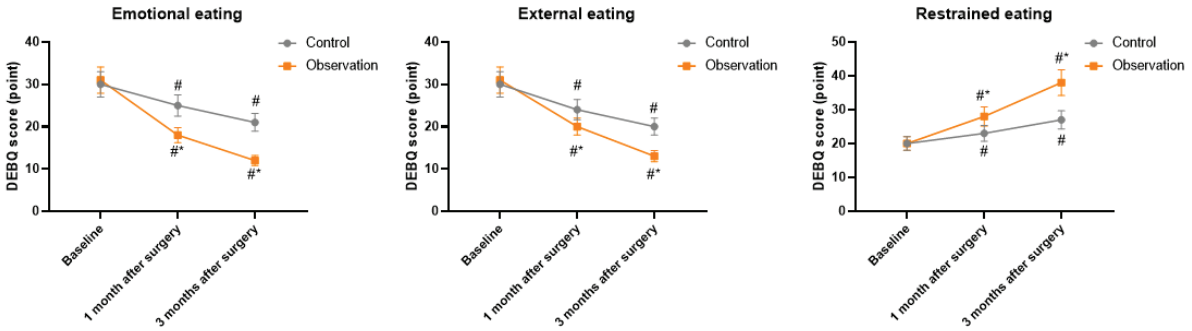

Fig. 3. Postoperative eating behavior of patients in the two groups. #$p<0.05$, vs baseline (ANOVA); *$p<0.05$, vs control group (t test).

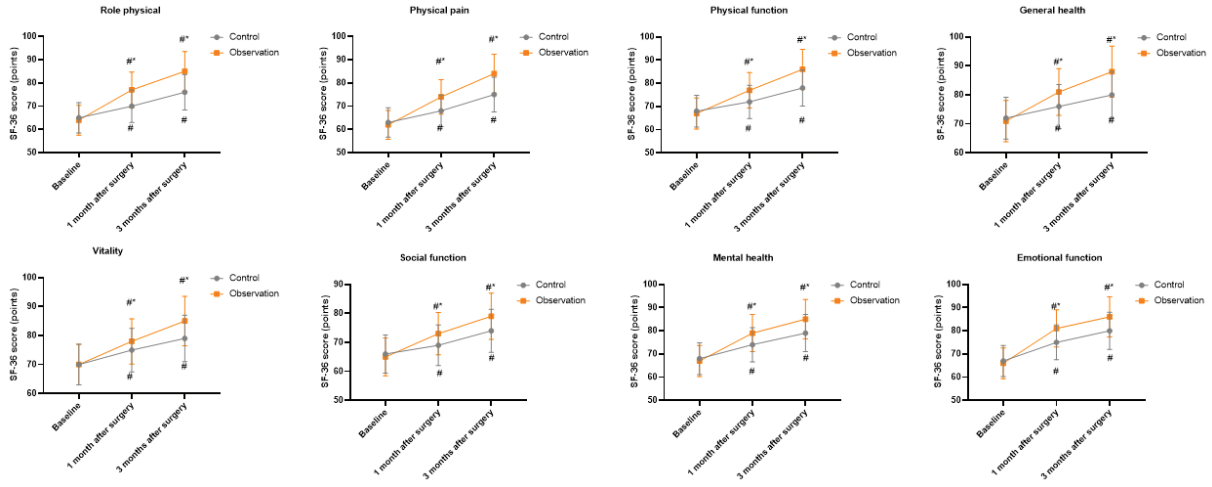

Fig. 5. Quality of life in the two groups. #p<0.05, vs baseline (ANOVA); *p<0.05, vs control group (t test). #p<0.05, vs baseline; *p<0.05, vs control group.

Table 3. Nursing satisfaction of patients in the two groups.

Groups	N	Satisfied	Barely satisfied	Dissatisfied	Total satisfaction
Control group	60	30 (50.00)	20 (33.33)	10 (16.67)	50 (83.33)
Observation group	60	35 (58.34)	23 (38.33)	2 (3.33)	58 (96.67)
χ^2					5.926
p					0.014

Data is expressed as n (%).

and fat accumulation can significantly extend national life expectancy and reduce the financial burden of health care [3]. Current approaches to weight loss include lifestyle interventions, medication, and surgery [27]. Some weight-loss medications, particularly older-generation agents, have been associated with neuropsychiatric side effects such as anxiety, insomnia, or mood changes, but these risks vary significantly depending on the specific drug and patient profile. Newer agents (e.g., GLP-1 receptor agonists) have shown a favorable safety profile in clinical trials, with few reports of severe mental health effects [28-31]. Protein isolates—particularly whey protein isolate—are known to provide highly bioavailable protein and have been shown to support muscle mass retention in postoperative patients. However, protein supplements' bioavailability and nutritional value vary considerably depending on their source, formulation, and protein concentration. For example, whey protein concentrates typically contain less protein and more lactose and fat than isolates, while protein waters may vary widely in their protein type and quantity. Most standard protein supplements also lack the comprehensive micronutrient profile found in complete protein meal replacements designed for bariatric patients. Therefore, accurate protein type and nutrient content specification is essential when interpreting their clinical impact.

However, after long-term practice, it has been found that many patients have reduced self-control after surgery and find it challenging to maintain good habits, which seriously affects the therapeutic effect of oral nutritional supplements [34]. The case-management model is a new nursing work and service concept that extends and continues the current holistic nursing model [35].

In the case-management model, the nurse plays the role of the person in charge of case management, is responsible for coordinating and communicating with doctors, medical teams and patients, formulating disease treatment plans and objectives, adjusting the plans based on the patient's situation, and constantly meeting the requirements of patients, so that they can achieve expectations within the scheduled period and have good clinical application effects [36].

Most anthropometric parameters, such as waist circumference, hip circumference, height, weight, and BMI, were used to assess the weight loss effect of patients after bariatric surgery. However, these indicators could not accurately reflect the body fat percentage and muscle content of obese patients, which had certain limitations [37]. The International Obesity Research Organization has indicated that the use of various tools to assess nutritional status, thereby improving treatment and medical nutritional support, is highly likely to decrease the morbidity burden of obese patients, so a growing number of studies have begun to focus on changes in body composition of patients after bariatric surgery [38]. After this procedure, changes in body composition, such as a sustained reduction in fat mass, are often associated with the inevitable loss of FFM [11]. Excessive loss of FFM is undesirable because FFM is responsible for most of the resting metabolic rate, regulating core body temperature, maintaining bone integrity, and maintaining function and quality of life as the body ages [39]. In our study, the results indicated that one and three months after surgery, the improvements of body fat percentage, FFM, BMI, body weight, skeletal muscle mass and excess weight loss rate in the observation group were more significant, suggesting that oral nutritional supplementation in the case management model could improve the body composition of patients after bariatric surgery. Consistently, Grupińska et al. suggested that oral nutritional supplements could improve body composition in women with breast cancer undergoing chemotherapy [40].

Moreover, our study also showed that at one and three months after the operation, relative to the control group, the improvements of the scores of emotional eating, external eating and restrained eating, as well as BSSQ scores in the observation group, were more significant. Meanwhile, at one and three months after the operation, relative to the control group, the scores of physical function, social function, physical pain, emotional function, general health, mental health, role physical, and vitality in the observation group were higher, suggesting that oral nutritional supplementation in the case management model could promote postoperative self-management ability, dietary compliance and quality of life in patients after bariatric surgery. In addition, we also found that oral nutritional supplementation in the case management model could enhance the nursing satisfaction of patients after bariatric surgery, which was in line with a study proposed by Dong et al. [46]. Although both groups received the same standard bariatric multivitamin complex, we acknowledge that the effects of vitamin supplementation could have interacted with or amplified the effects of oral nutritional supplements (ONS), particularly on markers of nutritional status such as hemoglobin, albumin, and protein levels. Therefore, while efforts were made to isolate the impact of ONS, micronutrient correction via vitamin intake may have contributed to improved outcomes, potentially confounding the degree to which results can be attributed to ONS alone. Future studies may consider a factorial design or biochemical monitoring of micronutrient levels to better disentangle these effects.

In conclusion, oral nutritional supplementation in the case-management model can improve body composition, promote nutritional status, reduce the incidence of complications, promote postoperative self-management ability, and enhance the quality of

life and nursing satisfaction in patients after bariatric surgery.

Recommendation

Future studies and clinical programs should prioritize the integration of registered clinical dietitians into case management models for postoperative bariatric patients. Including dietitians in multidisciplinary teams can ensure evidence-based, individualized nutritional care, leading to better outcomes in body composition, nutritional status, complication rates, and patient satisfaction. Institutional support to recruit and embed clinical dietitians into surgical and nutritional care pathways should be a strategic priority to align with international best practices.

Limitation

One notable limitation of our study is the prolonged timeline of postoperative diet advancement, with soft foods introduced only after six weeks postoperatively, lasting until week 12. This approach deviates from widely accepted post-bariatric surgery protocols in other regions, where soft foods are typically introduced by week 4, with transition to solid textures occurring by weeks 6–8. While our institution adopted a conservative progression to minimize gastrointestinal complications, this prolonged dietary restriction may have introduced confounding variables. Without personalized nutritional supplementation, patients in the control group may have experienced greater caloric deficits, reduced protein intake, and heightened dietary restraint—factors that could influence body composition, nutritional status, and psychological outcomes such as restrained eating. These effects may have amplified the observed benefits in the intervention group. Future studies should consider aligning with standard international diet progression guidelines to ensure broader generalizability and minimize the confounding impact of diet texture timelines.

A significant limitation of this study is the lack of objective, standardized tracking of dietary and vitamin intake in the control group. While the observation group utilized a digital app for real-time tracking and individualized ONS adjustments, intake data from the control group were based on self-reported logs and verbal follow-ups, which may introduce recall bias or underreporting. Furthermore, biochemical assessments of individual micronutrients were not conducted, limiting our ability to distinguish the effects of vitamin supplementation from the ONS protocol. This discrepancy in intake monitoring between groups may affect the accuracy of outcome comparisons.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

Number ORCID of authors

- Juan Cheng: 0009-0008-3989-8416
- Yu Guo: 0009-0005-1230-5682

Credit authorship contribution statement

JC designed the study, collected data, and drafted the manuscript. YG performed data analysis, revised the manuscript, and drew figures.

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