https://doi.org/10.46389/rjd-2024-1761
www.rjdnmd.org

Rom J Diabetes Nutr Metab Dis
2024; volume 31, issue 4, pages 386–392

Original Article

# The effect of a plant-based diet in post-surgical bariatric surgery patients in a reference obesity unit in Mexico

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Received: 29 August 2024 / Accepted: 12 November 2024

## Abstract

Post-bariatric surgery patients need nutritional treatment after surgery, focusing on preventing patients from developing dietary deficiencies. This study analyzed the effect of a plant-based diet in post-bariatric surgery patients. A cohort study compared the anthropometric and biochemical parameters from two groups of adult patients. One group followed a conventional diet (n=30), and the other followed a plant-based diet (ovolactovegetarian) (n=20). Two measurements were performed, the first at the beginning of treatment and the second six months later. After six months of dietary follow-up assisted by a nutrition professional, both groups had similar weight loss percentages, BMI, waist circumference, and visceral fat score. Related to anthropometric indicators, only fat mass loss percentage had significant differences, which was higher in the conventional diet group. In regard to biochemical values, similar albumin, glucose, and iron-blood values were found in both groups after six months of treatment. The group of patients who performed a plant-based diet reached similar biochemical and anthropometric values as those found in the conventional diet group after a six-month period.

**Keywords:** plant-based diet, vegetarian diet, post-bariatric surgery patients, obesity, nutrition therapy, bariatric-metabolic-surgery.

## Introduction

Obesity is known as a disease associated with a chronic low-grade inflammatory state and immune dysfunction. This persistent inflammation status is believed to cause an imbalance of homeostatic mechanisms and, consequently, metabolic diseases. Although non-surgical treatment options are available, long-term studies have demonstrated that bariatric and metabolic surgeries (BMS) are an effective and long-lasting treatment against severe obesity and its comorbidities [1]. In the post-surgery period of BMS, patients begin a dietary plan designed with different stages, which aim to meet the needs of essential nutrients, help with weight loss, continue with healthy habits, and provide foods with an adequate feature that enables its tolerance [2], notwithstanding this, those patients with BMS often present food intolerances, and among these, intolerance to red meat [3]. This has been observed in the clinical practice of this research team, in addition to identifying intolerance to chicken and even fish. Intolerance to red meat is a concern in patients with BMS due society puts pressure on them to consume meat and avoid forthcoming nutritional deficiencies.

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Among the dietary treatment options are plant-based diets (PBDs), which integrate different nutritional patterns with a high content of plant sources, such as whole grain cereals, oilseeds, fruits, vegetables, healthy fats, and legumes, and almost entirely exclude animal meat, such as beef, poultry, seafood, fish and other animal-related products [4]. Among the most common PBDs are vegetarian diets: lacto-ovo-vegetarian, lacto-vegetarian, ovo-vegetarian, vegan, and raw vegan [5].

The Academy of Nutrition and Dietetics states that there is a reduced intake of certain nutrients in PBDs. However, deficiencies can be easily prevented through appropriate diet planning according to life cycle stages, including pregnancy, lactation, infancy, childhood, adolescence, adulthood and athletes [5]. Furthermore, people who follow a PBD have lower serum concentrations of total cholesterol (TC), Low-Density Lipoprotein (LDL), and glucose, in addition to a reduced risk of incidence and mortality related to ischemic heart disease (IHD) and the incidence of cancer in general, compared to people who follow an omnivorous diet [6]. However, authors have demonstrated that PBD interventions produce a greater reduction in body mass index (BMI) compared to the omnivorous diet and promote the decrease of total and visceral fat mass [7, 8].

According to the reported benefits of PBD, this could be a good treatment option for patients with BMS. However, there is concern about possible deficiencies in these patients, like poor nutrient absorption due to the surgery itself. This study aims to analyze the effect of a plant-based diet in post-bariatric surgery patients.

## Material and methods

### Study design and data collection

A cohort study was conducted in a public hospital in Guadalajara, Jalisco, Mexico. The research was approved by the Hospital Ethics Committee, and the registration code 0439/20HCJIM/2020 was obtained. All relevant national regulations and institutional policies, including the principles of the Declaration of Helsinki, were considered.

Patient information was taken from the records of the Hospital's Bariatric Service. From a total of 265 patients who were treated in the service during the year 2019, only 50 were considered since the others did not meet the inclusion criteria: having undergone bariatric surgery (gastric bypass), having undergone nutritional treatment after surgery, having a complete record of the anthropometric measurements considered in the study both at the initial consultation and at month 6, and having attended at least 5 follow-up sessions between the start of treatment and month 6.

It is important to mention that the hospital's nutritional treatment for bariatric surgery patients has four stages: 3 days of clear liquids, 12 days of general liquids, and 15 days of porridge and purees until reaching the soft diet to promote readaptation to a whole diet, healing improvement and nutrient absorption. In the final stage, post-bariatric patients and the hospital nutrition staff decide whether they will follow a conventional or plant-based diet.

The 50 patients in the sample were divided into two groups: plant-based diet (PBD) (n=20) and conventional diet (CD) (n=30). Both groups included 60 g of hydrolyzed protein as a supplement.

In the conventional diet group, there are patients who, throughout the nutritional treatment, were prescribed a diet with 60–75 g of protein, 20% fat, and 50% carbohydrates, with an approximate consumption of 800 to 1000 kcal, without excluding meat products.

Age and sex data were collected from each patient, as well as anthropometric measurements such as weight, height, body mass index (BMI), waist circumference (WC), water percentage, fat mass (FM) percentage, visceral fat (VF) and muscle mass (MM) percentage. In addition, other relevant information was taken on the consumption of supplements (protein, multivitamins, calcium, vitamin B12, and iron), physical activity (PA), time spent doing PA, days per week doing PA, concentrations of albumin, glucose, blood-iron levels and total protein, both from the first session and after six months of treatment.

Furthermore, the change percentage in the anthropometric variables was calculated between the baseline measurement and the one obtained at six months to compare groups.

### Statistical analysis

The statistical analysis was performed as follows: for statistical descriptions, measurements such as frequencies, percentages, means, and standard deviations (SD). For statistical significance, the Mann-Whitney U test and the Wilcoxon test were applied for numerical variables, as well as the Chi-square test and Fisher's exact test for categorical variables. Statistical significance of $p \leq .05$ was used. For the data management and analysis, Excel® (Microsoft, Redmond, WA, USA) and IBM SPSS Statistics Processor version 25 were used.

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## Results

Data from 50 patients divided into two groups were evaluated: 20 were in the plant-based diet group, and 30 were in the conventional diet group. A 95% of the members of the PBD group were women (19 people), while in the CD group, women represented 93.3% (28 people) (p=.651). There were no significant differences in the mean age of both groups (p=.336); in the PBD group, it was 38.5 years (SD=13.67), while in the CD group, it was 33.83 years (SD=7.98).

Table 1 compares anthropometric measurements at the beginning and after 6 months of treatment. Regarding the average weight at the beginning of each group, PBD=120.75 kg and CD=122.9 kg, there were no significant differences (p=.766). Likewise, after six months of treatment, the kilograms lost in both groups were similar (p=.559). Regarding the average percentage of weight lost after six months, although it was higher in the PBD group, the difference was insignificant (p=.722).

Regarding BMI, WC and VF scores, punctual losses and the percentage of fat loss were statistically similar for both compared groups: the one with the PDB treatment and the conventional diet group (CD) (Table 1).

Observing the percentage of water, the groups started with different percentages; the CD group started with an average of 44.09% and the PBD group with 39.17% (p=.019); however, at six months of treatment, the difference in the percentage of water between both groups was no longer significant (p=.586). The average percentage of water gain was higher in the PBD group (14.66, SD 18.32) than in the CD group (2.17, SD 15.11), with a p=.001 (Table 1).

In the percentage of FM, in Table 1, it can be observed that both groups started the treatment without

Table 1: Comparison of anthropometric measurements at the beginning and after six months of treatment according to the type of diet.

| | | PBD (n=20) mean (SD) | CD (n=30) mean (SD) | p* |
|---|---|---|---|---|
| **Weight** | Initial (kg) | 120.75 (20.33) | 122.90 (18.73) | .766 |
| | 6 months (kg) | 88 (12.68) | 91.94 (14.14) | .559 |
| | Loss at 6 months (%) | 26.24 (6.54) | 24.98 (9.46) | .722 |
| **BMI** | Initial (k/m²) | 44.61 (6.35) | 44.23 (6.52) | .984 |
| | 6 months (k/m²) | 32.57 (4.01) | 33.23 (5.53) | .898 |
| | Loss at 6 months (%) | 26.42 (6.46) | 24.47 (9.5) | .464 |
| **WC** | Initial (cm) | 129.73 (14.63) | 123.75 (17.51) | .120 |
| | 6 months (cm) | 104.96 (11.42) | 95.76 (16.85) | .083 |
| | Loss at 6 months (%) | 18.57 (8.91) | 22.52 (8.88) | .303 |
| **Water percentage** | Initial (%) | 39.17 (5.69) | 44.09 (7.78) | .019 |
| | 6 months (%) | 44.19 (5.51) | 44.88 (9.09) | .586 |
| | Increases at 6 months (%) | 14.66 (18.32) | 2.17 (15.11) | .001 |
| **FM percentage** | Initial (%) | 49.41 (7.64) | 50.47 (5.56) | .812 |
| | 6 months (%) | 40.78 (8.61) | 34.34 (9.03) | .012 |
| | Loss at 6 months (%) | 16.42 (18.63) | 31.66 (17.12) | .009 |
| **VF percentage** | Initial | 12.5 (3.89) | 13.4 (3.38) | .283 |
| | 6 months | 9.05 (2.72) | 8.57 (2.39) | .644 |
| | Loss at 6 months (%) | 25.06 (19.77) | 33.92 (16.58) | .187 |
| **MM percentage** | Initial | 20.59 (3.47) | 27.17 (3.88) | .000 |
| | 6 months | 26.13 (4.5) | 27.02 (4.05 | .125 |
| | Increases at 6 months (%) | 29.39 (25.34) | -0.05 (10.31) | .000 |

Note: SD – standard deviation; BMI – body mass index; WC – waist circumference; FM – fat mass; VF – visceral fat; MM – muscle mass; * – Mann-Whitney U test.

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significant differences (p=.812); however, at six months, the PBD group presented a higher average percentage of fat mass (40.78%) compared to the CD group (34.34%) with statistically significant differences (p=.012), as well as the average percentage of fat mass loss at six months of treatment, where the PBD group had 16.42% compared to 31.66% of the CD group (p=.009).

The last anthropometric measure assessed was the percentage of MM; it was observed that the CD group started with a higher percentage (27.17) compared to the PBD group (20.59), where a statistically significant difference was observed at the beginning (p=.000). At six months of treatment, the mean percentage of MM in both groups was similar (PBD=26.13; CD=27.02; p=.125). Regarding the mean percentage of MM gain between the groups, the score of the PBD group (29.39%) was statistically higher (p=.000) than the CD group (-0.05%), showing a slight decrease instead of showing a gain (Table 1).

In Table 2, the percentage of people who consumed the supplements was similar in both groups (all with p-values higher than .05), except for blood-iron, where the observed p-value is higher in the CD group (86.6%) compared to the PBD group (10%) (p=.000).

Regarding physical activity (PA), there were no significant differences in the percentage of people who did PA at the beginning of the treatment (PBD=85%, CD=70%, p=.317); the same occurred when comparing the groups at six months (PBD=70%, CD=86.6%, p=.171). However, at the beginning of treatment, the PBD group invested twice as much time (50.25 min *versus* 25.16 min) in PA per week compared to the CD group (p=.005). During the six months of treatment, the time of both groups was the same (PBD=43.25 min, CD=45.16, p=.691). Regarding the days per week performing physical activity, both groups started with no significant differences (p=.336). These values remained equal after six months (Table 3).

As Table 4 shows, the concentrations of albumin, glucose, and blood iron were not significantly different at the beginning of treatment (p>0.05). Only in the case of total protein concentration, the CD group showed a higher concentration (7.22 g/dL) than the PBD group (6.95 g/dL) (p=0.049). In the measurement taken at six months of treatment, there were no significant differences between the concentrations of the groups (p>0.05) in these variables.

However, when comparing the variations between the initial mean concentrations and at six months of treatment, only total proteins and glucose had statistically significant differences. Regarding glucose, a decrease of 13.67 mg/dL in the PBD group was observed (p=.002), while in the CD group, the reduction was 23.49 mg/dL (p=.001). The same occurred with the concentration of total proteins in the CD group; a decrease of .25 g/dL was observed (p=.005) (Table 5).

## Discussion

This study aimed to describe and understand the effects of a plant-based diet on nutritional status in post-BMS patients. To our knowledge, the scientific literature documenting the effect of a plant-based diet

Table 2: Supplementation consumption according to the type of diet.

| | | PBD (n=20) n (%) | CD (n=30) n (%) | p* |
|---|---|---|---|---|
| **Protein** | No | 4 (20) | 1 (3.3) | .125 |
| | Yes | 16 (80) | 29 (96.6) | |
| **Multivitamin** | No | 3 (15) | 1 (3.3) | .246 |
| | Yes | 17 (85) | 29 (96.6) | |
| **Calcium** | No | 4 (20) | 2 (6.6) | .275 |
| | Yes | 16 (80) | 28 (93.3) | |
| **Vitamin B12** | No | 3 (15) | 2 (6.6) | .464 |
| | Yes | 17 (85) | 28 (93.3) | |
| **Iron** | No | 18 (90) | 4 (13.3) | .000 |
| | Yes | 2 (10) | 26 (86.6) | |

Note: * – Chi-square test.

Table 3: Comparison of physical activity performed at the beginning and after six months of treatment according to the type of diet.

| | | | PBD (n=20) n (%) | CD (n=30) n (%) | p* |
|---|---|---|---|---|---|
| **Physical activity (PA)** | Initial | No | 3 (15) | 9 (30) | .317 |
| | | Yes | 17 (85) | 21 (70) | |
| | At 6 months | No | 6 (30) | 4 (13.3) | .171 |
| | | Yes | 14 (70) | 26 (86.6) | |
| | | | **mean (SD)** | **mean (SD)** | **p**** |
| **Time per week dedicated to PA** | | Initial (min) | 50.25 (32.5) | 25.16 (21.1) | .005 |
| | | At 6 months (min) | 43.25 (39.5) | 45.16 (28.7) | .691 |
| **Days per week that PA was performed** | | Initial (days) | 4.1 (2.36) | 3.57 (2.12) | .336 |
| | | At 6 months (days) | 2.95 (2.3) | 4.17 (1.88) | .059 |

Note: * – Fisher's exact test; ** – Mann Whitney U test.

Table 4: Comparison of blood concentrations of albumin, glucose, iron and total protein at baseline and after six months of treatment between the two types of diet.

| | | PBD (n=20) mean (SD) | CD (n=30) mean (SD) | p* |
|---|---|---|---|---|
| **Albumin (g/dL)** | Initial | 4.24 (1.3) | 4.06 (0.4) | .585 |
| | At 6 months | 3.77 (0.96) | 4.15 (0.48) | .108 |
| **Glucose (mg/dL)** | Initial | 99.72 (15.4) | 116.71 (66.79) | .627 |
| | At 6 months | 86.05 (13.91) | 93.22 (28.8) | .593 |
| **Iron (mcg/dL)** | Initial | 76.38 (29.14) | 73.66 (29.45) | .714 |
| | At 6 months | 82.37 (41.77) | 85.38 (42.5) | .501 |
| **Total proteins (g/dL)** | Initial | 6.95 (0.47) | 7.22 (0.36) | .049 |
| | At 6 months | 6.93 (0.47) | 6.97 (0.45) | .758 |

Note: * – Mann Whitney U test.

Table 5: Comparison of blood concentrations of albumin, glucose, iron and total protein at baseline and after six months of treatment by type of diet (n=50).

| | | Initial mean (SD) | At 6 months mean (SD) | Mean difference | p* |
|---|---|---|---|---|---|
| **Albumin (g/dL)** | PBD | 4.24 (1.3) | 3.77 (0.96) | -0.45 | .408 |
| | CD | 4.06 (0.4) | 4.15 (0.48) | .09 | .434 |
| **Glucose (mg/dL)** | PBD | 99.72 (15.4) | 86.05 (13.91) | -13.67 | .002 |
| | CD | 116.71 (66.79) | 93.22 (28.8) | -23.49 | .001 |
| **Iron (mcg/dL)** | PBD | 76.38 (29.14) | 82.37 (41.77) | 5.99 | .502 |
| | CD | 73.66 (29.45) | 85.38 (42.5) | 11.72 | .399 |
| **Total proteins (g/dL)** | PBD | 6.95 (0.47) | 6.93 (0.47) | -.02 | .812 |
| | CD | 7.22 (0.36) | 6.97 (0.45) | -.25 | .005 |

Note: * – Wilcoxon test.

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on these patients is scarce. Therefore, our study significantly contributes to advancing comprehension on this topic.

In a recent study by Vilela *et al.* [9], it was observed that every 5% of energy from vegetable protein replaced by animal protein (mainly white meat) after Roux-en-Y gastric bypass increased the probability of obesity remission (BMI reduction to at least 29.9 kg/m$^2$). Contrasting their results, during a 6-month follow-up, we did not observe significant differences in mean weight in kilograms, percentage of weight loss, BMI, WC, and VF score between both groups. This is consistent with a study by Phan *et al.* [10], in which no significant differences in weight loss and BMI were observed between vegetarian and omnivorous patients 6 months after BMS.

No significant differences were observed in the mean percentage of MM at 6 months between both groups. However, a significant difference was observed in the mean percentage of MM gain, resulting greater in the PBD group compared to the CD group, which had a slight decrease. This difference could be due to the higher protein consumption in the PBD group (PBD=90 g of protein/day; CD=60–75 g of protein/day) since some studies suggest that "the best predictor" to keep muscle mass is a higher protein intake. Authors have reported that vegetable-protein consumption increases protein amount, as well as an adequate branched amino acids intake, which is related to higher protein synthesis and muscle mass preservation. However, there has yet to be a scientific consensus about which type of protein (animal or vegetable) is better for protein synthesis and muscle mass. Therefore, it cannot be concluded whether the difference found in the average MM gain is due to the type of diet consumed. Furthermore, the group that carried a PBD also consumed foods from animal sources, including eggs and dairy products [11].

Significant differences were observed in terms of FM. The PBD group had a higher average FM percentage than the CD group, and the percentage of FM loss was higher in the CD group than in the PBD group.

PA could have also influenced the differences in the variables of MM and FM; however, authors have stated that physical activity impacts body composition. Willis *et al.* [12] compared aerobic exercise (AE), resistance exercise (RE), and a combination of both (AE/RE) to identify which was the best option for reducing obesity. These authors found that the AE and AE/RE groups reduced fat mass more than the RE, while RE and AE/RE increased lean body mass more than AE. Nonetheless, in this study, we only had PA time, which was greater at the beginning of treatment in the PBD group; they spent twice as much time in PA per week. After 6 months of intervention, the time was equal between both groups. The type and intensity of physical activity they performed need to be known in order to carry out a more detailed analysis.

Regarding blood concentrations, our results match the study by Phan A. *et al.* [10]; no significant differences were observed in iron-blood and albumin blood concentrations between both groups at 6 months after surgery. Likewise, in our results, no significant differences were observed in blood concentrations of glucose and total protein between both groups. However, when comparing the initial concentrations with those at 6 months by type of diet, significant differences were found; in both groups, a significant decrease in glucose levels was found. A slight decrease in total protein concentration was detected in the CD group.

In Israel, Sherf-Dagan *et al.* [13] reported that greater iron supplementation was detected among vegetarians compared to omnivores; contrasting, we observed that the percentage of people with CD who consumed iron supplements was higher. This may be due to vegetarianism differences and the availability of certain products between Israel and Mexico.

Regarding the limitations of this study, the only comparison between the ovo-lacto-vegetarian diet is not enough to know the effects of other types of plant-based diets, such as the vegan diet. Consequently, it is necessary to address this in the following studies.

Although the patients were asked in the nutrition consultation if they kept a PBD, consumed supplements, and had a high level of physical activity, there is a possibility of bias due to the person's memory capacity or the fact that being honest in their answers cannot be prevented. In addition, a small sample size was available due to the low rate of patients with a PBD who undergo a BMS, so the validity and generalization of the results may be affected.

Regarding this study's strengths, we can remark on its design, as it was possible to perform a longitudinal comparison of both study groups. Furthermore, data were available on the evolution of lean mass and fat mass in addition to consumption/adherence to supplementation, which are essential elements for analyzing patients' nutritional status.

A recommendation for upcoming research is to analyze the blood concentration of vitamin B12 since lower levels of this vitamin have been observed in some studies in people living overweight and obese compared to people of normal weight. Low B-12 vitamin blood levels have also been reported as a common deficiency among

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vegetarians [10, 13, 14]. It would also be pertinent to analyze the concentrations of other vitamins and minerals, such as vitamin D, zinc, and calcium, as these deficiencies may be present in people with PBD [10, 13].

## Conclusions

The results of this study suggest that after six months of treatment, the nutritional status of people who followed a PBD after a BMS such as gastric bypass was the same as that of those who followed a provided CD, even when the treatment was monitored and planned by a nutrition professional.

Nevertheless, it is essential to supervise the quality of the PBD and identify and amend possible deficiencies associated with unhealthy nutrition habits. It is a common practice in post-bariatric patients to avoid the consumption of animal-based foods, and they tend to have a greater intake of ultra-processed products.

## Conflict of interest

The authors declare no conflict of interest.

## References


1. Eisenberg D, Shikora SA, Aarts E, et al. 2022 American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO): Indications for Metabolic and Bariatric Surgery. Surg Obes Relat Dis 18(12):1345-1356, 2022. Doi:10.1016/j.soard.2022.08.013
2. Carranza TR, Girón ALT, Serna-Thomé MG. Tratamiento nutricional en el paciente con superobesidad y bypass gástrico en Y de Roux. Nutr Clin Med XI(1):42-58, 2017. Doi:10.7400/NCM.2017.11.1.5049
3. Sherf-Dagan S, Biton R, Ribeiro R, et al. Nutritional and Lifestyle Behaviors Reported Following One Anastomosis Gastric Bypass Based on a Multicenter Study. Nutrients 15(6):1515, 2023. Doi:10.3390/nu15061515
4. Soto-Aguilar BF, Webar J, Palacios I. Alimentación basada en plantas. Sus mecanismos en la prevenci´pin y tratamiento de la obesidad. Rev Fac Med Hum 22(1):162-170, 2022. Doi:10.25176/RFMH.v22i1.3616
5. Melina V, Craig W, Levin S. Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. J Acad Nutr Diet 116(12):1970-1980, 2016. Doi:10.1016/j.jand.2016.09.025
6. Dinu M, Abbate R, Gensini GF, et al. Vegetarian, vegan diets and multiple health outcomes: A systematic review with meta-analysis of observational studies. Critical Reviews in Food Science and Nutrition 57(17):3640-3649, 2017. Doi:10.1080/10408398.2016.1138447
7. Kahleova H, Fleeman R, Hlozkova A, et al. A plant-based diet in overweight individuals in a 16-week randomized clinical trial: metabolic benefits of plant protein. Nutr Diabetes 8(1):58, 2018. Doi:10.1038/s41387-018-0067-4
8. Gogga P, Śliwińska A, Aleksandrowicz-Wrona E, et al. Association between different types of plant-based diets and leptin levels in healthy volunteers. Acta Biochim Pol 66(1):77-82, 2019. Doi:10.18388/abp.2018_2725
9. Vilela DLS, Silva A, Pinto SL, et al. Animal Protein Intake Is Associated with Obesity Remission After Roux-en-Y Gastric Bypass: an Isocaloric Replacement Analysis. Obes Surg 33(5):1382-1389, 2023. Doi:10.1007/s11695-023-06539-w
10. Phan A, Hage M, Zaharia R, et al. Nutritional Status of Vegetarian Patients Before and After Bariatric Surgery: a Monocentric Retrospective Observational Case-Control Study. Obes Surg 33(5):1356-1365, 2023. Doi:10.1007/s11695-023-06538-x
11. Ewy MW, Patel A, Abdelmagid MG, et al. Plant-Based Diet: Is It as Good as an Animal-Based Diet When It Comes to Protein?. Curr Nutr Rep 11(2):337-346, 2022. Doi:10.1007/s13668-022-00401-8
12. Willis LH, Slentz CA, Bateman LA, et al. Effects of aerobic and/or resistance training on body and fat mass in overweight or obese adults. J Appl Physiol 113(12):1831-1837, 2012. Doi:10.1152/japplphysiol.01370.2011
13. Sherf-Dagan S, Hod K, Buch A et al. Health and Nutritional Status of Vegetarian Candidates for Bariatric Surgery and Practical Recommendations. OBES SURG 28:152-160, 2018. Doi:10.1007/s11695-017-2810-7
14. Mohapatra S, Gangadharan K, Pitchumoni CS. Malnutrition in obesity before and after bariatric surgery. Dis Mon 66(2):100866. Doi:10.1016/j.disamonth.2019.06.008



https://doi.org/10.46389/rjd-2024-1761
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