Original Article

Adherence to the Mediterranean diet and cardiometabolic risk factors in morbid obese patients candidate for bariatric surgery

Fatemeh S. Hosseini[1], Seyed Ali Keshavarz[*2], Hastimansooreh Ansar[*3]

1- Department of Nutrition, Science and Research Branch, Islamic Azad University, Tehran, Iran.

2- Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran.

3- Department of Cellular and Molecular Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Science, Tehran, Iran.

Received: August 2025 **Accepted:** November 2025

ABSTRACT

Background and Objectives: Morbid obesity significantly increases the risk of cardiometabolic disorders, complicating bariatric surgery outcomes. This study assessed the association between adherence to the Mediterranean diet (MD) and cardiometabolic risk factors among morbidly obese individuals undergoing bariatric surgery evaluation.

Materials and Methods: A cross-sectional study was conducted with 369 morbidly obese patients (BMI ≥ 40 kg/m² or BMI ≥35 kg/m² with comorbidities) referred to Hazrat Rasul Akram Hospital obesity clinic between September 2023 and September 2024. Dietary intakes were evaluated by a validated food frequency questionnaire. Cardiometabolic risk factors were assessed according to ATP III criteria, including blood pressure, fasting blood sugar (FBS), triglycerides (TG), HDL cholesterol, and anthropometric measurements. Participants were categorized into quartiles based on MD adherence.

Results: Participants in the highest quartile of MD adherence exhibited significantly lower odds of elevated blood pressure (OR=0.34, 95% CI: 0.16–0.70, p-trend=0.01), low HDL cholesterol levels (OR=0.34, 95% CI: 0.16–0.70, p-trend=0.03), and elevated fasting blood sugar (OR=0.42, 95% CI: 0.20–0.87, p-trend=0.03). No significant associations were found for triglyceride levels.

Conclusions: Higher adherence to the MD is inversely associated with key cardiometabolic risk factors among morbidly obese patients preparing for bariatric surgery. These results support integrating MD-based dietary interventions into preoperative nutritional counselling to improve cardiometabolic outcomes and surgical success.

Keywords: Mediterranean diet, Cardiometabolic risk factors, Bariatric surgery

Introduction

Obesity has become a major global health crisis, with its prevalence steadily increasing over the past decades (1). Among individuals with obesity, morbid obesity—defined as a body mass index (BMI) of ≥40 kg/m² or ≥35 kg/m² with obesity-related comorbidities—poses significant health challenges, including an increased risk of cardiovascular diseases (CVD), type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, and metabolic syndrome (1). These conditions not only contribute to increased morbidity and mortality but also impose a considerable economic and healthcare burden globally (2). Among the available treatment strategies, bariatric surgery has emerged as the most effective long-term intervention for significant weight loss and the resolution of obesity-related metabolic disorders (3). While bariatric surgery has been shown to improve metabolic health through mechanisms such as hormonal modulation, reduced caloric intake, and enhanced insulin sensitivity, the role of preoperative dietary patterns in shaping metabolic outcomes remains an area of growing interest (4). Nutritional optimization before surgery is increasingly recognized as a key factor in improving surgical outcomes, reducing perioperative complications, and enhancing long-term metabolic benefits (5). Identifying dietary patterns that positively influence cardiometabolic risk factors in this high-risk population could provide valuable insights into preoperative dietary interventions that improve both immediate and long-term health outcomes.

***Address for correspondence:** **Seyed Ali Keshavarz, PhD,** Department of Clinical Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran. Email: s_akeshavarz@yahoo.com
Hastimansooreh Ansar, PhD,Department of Cellular and Molecular Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Science.Email: hastiansar@gmail.com

[DOI: 10.66224/nfsr.13.1.45]

The Mediterranean diet (MD) is a well-recognized dietary pattern characterized by a high intake of fruits, vegetables, whole grains, legumes, nuts, and olive oil; a moderate intake of fish, dairy, and wine; and a low intake of red meat and processed foods (6). The Mediterranean Diet Score is a validated tool commonly used to assess adherence to the MD, with higher scores indicating greater adherence to this beneficial dietary pattern (7). Several studies have demonstrated the positive impact of the MD on weight management and metabolic health in individuals with overweight and obesity (6, 8). However, limited research has specifically examined the relationship between adherence to the MD and cardiometabolic risk factors in morbidly obese patients preparing for bariatric surgery. Given that preoperative nutritional status may influence both short-term surgical outcomes and long-term weight maintenance, understanding the role of the MD in this high-risk population is of particular importance (5).

Despite the well-documented benefits of the MD in promoting cardiovascular and metabolic health, research examining its association with cardiometabolic risk factors among morbidly obese individuals preparing for bariatric surgery remains limited. Identifying dietary strategies that enhance preoperative cardiometabolic profiles could have significant implications for postoperative outcomes. Therefore, this study aimed to investigate the association between adherence to the MD, as assessed by the MD, and key cardiometabolic risk factors—including fasting blood sugar (FBS), triglycerides (TG), blood pressure (BP), and high-density lipoprotein cholesterol (HDL-C)—in morbidly obese patients who are candidates for bariatric surgery.

Materials and Methods

This cross-sectional study was conducted between September 2023 and September 2024 among individuals referred to the obesity clinic of Hazrat Rasul Akram Hospital using the convenience sampling method. The sample size for this study was determined based on a prior investigation that assessed the relationship between MD and obesity phenotype among Iranian obese adults (9). Using G*Power software, the sample size was calculated with the following parameters: alpha error probability of 0.05, power of 0.90, a mean MD of 4.0 ± 1.35, and an effect size of 1.3 (9), resulting in a minimum required sample size of 369 participants.

We included bariatric surgery candidates based on the following criteria: (1) they were between 18 and 65 years of age, (2) they had no medical conditions, as determined by a physician's evaluation and a comprehensive review of their medical history, including kidney or liver diseases (such as Wilson's disease, autoimmune liver disease, hemochromatosis, viral infections, and alcoholic fatty liver disease) or any malignancies, and (3) they were neither pregnant nor breastfeeding. The criteria for exclusion were as follows: individuals who (1) did not complete more than 90% of the descriptive and nutritional questionnaires, (2) lacked essential paraclinical data, including blood and anthropometric measurements, or (3) reported dietary energy intake that was significantly over- or under-represented, defined as values deviating by more than three standard deviations from the mean energy intake.

The study protocol was developed in accordance with the Helsinki Declaration and received approval from the ethics committee at Islamic Azad University, Science and Research Branch (Approval ID: IR.IAU.SRB.Rec.1403.543). We obtained written informed consent from all participants involved in the study.

Measurements

Trained nutritionists conducted anthropometric measurements utilizing standardized methodologies to ensure accuracy and reliability. Weight was measured to the nearest 100 grams with a calibrated scale (Seca, Hamburg, Germany), with participants advised to wear no additional clothing or shoes during the process. Height was assessed by the participants standing barefoot, employing a standard measuring tape that provides precision to 0.5 cm. Waist circumference (WC) was measured at the midpoint, specifically at the level of the umbilicus, using an unstretched tape measure to prevent any undue pressure on the body surface. BMI was calculated by dividing the weight in kilograms by the height in square meters.

Systolic and diastolic blood pressure measurements were conducted at least twice after a 5-minute resting period, at intervals of 15 minutes, using a mercury sphygmomanometer that has been calibrated by the National Institute of Standards and Industrial Technology. The average of these two measurements is used to determine an individual's blood pressure.

Blood samples were collected between 7:00 and 9:00 AM following a 12–14-hour overnight fasting period. Samples were centrifuged within 30–45 minutes of collection and analyzed on the same day to ensure precision and reliability. Fasting blood glucose levels were determined using an enzymatic colorimetric method based on glucose oxidase activity. TG concentrations were measured through an enzymatic colorimetric assay utilizing glycerol phosphate oxidase. Total cholesterol (TC) levels were assessed using an enzymatic colorimetric technique involving cholesterol esterase and cholesterol oxidase. HDL-C was quantified after the selective precipitation of apolipoprotein B-containing lipoproteins using phosphotungstic acid. Low-density lipoprotein cholesterol (LDL-C) concentrations were estimated using the Friedewald equation, which calculates LDL-C levels

[DOI: 10.66224/nfsr.13.1.45]

based on serum TC, TG, and HDL-C concentrations, with values expressed in mg/dL (10).

Cardiometabolic risk factors

According to the Adult Treatment Panel III (ATP III) criteria, cardiometabolic risk factors are defined based on specific clinical parameters (11). These include high FBS, characterized by a FBS≥100 mg/dL or a history of diabetes or use of glucose-lowering drugs. Hypertriglyceridemia is identified as serum triglyceride levels of ≥150 mg/dL. Low HDL-C levels are defined as HDL-C concentrations below 40 mg/dL in men and below 50 mg/dL in women. High BP is classified as systolic blood pressure of ≥130 mmHg and/or diastolic blood pressure of ≥85 mmHg or a history of antihypertensive medication use.

Participants' dietary intakes were evaluated using a validated and reliable semi-quantitative food frequency questionnaire (FFQ), which comprised 147 items (12, 13). A qualified dietitian administered this questionnaire during a structured in-person interview. Participants indicated the frequency of their consumption of each food item over the past year, selecting from daily, weekly, monthly, or yearly options. The serving sizes for each food item on the FFQ were standardized according to the guidelines established by the U.S. Department of Agriculture (USDA) whenever feasible. In instances where this information was unavailable, household measurements were recorded and subsequently converted into grams and servings to ensure accuracy and consistency.

The MD was assessed based on the methodology established by Trichopoulou et al., incorporating eight key dietary components characteristic of the MD (7). These components included a higher intake of vegetables, legumes, nuts and fruits, and cereals, and a favorable monounsaturated to saturated fatty acid (MUFA/SFA) ratio; moderate consumption of fish; a low-to-moderate intake of dairy products, primarily cheese and yoghurt; and a limited intake of meat and poultry. To ensure comparability, all dietary components were adjusted for energy intake using the energy density method (grams per 1000 kcal). The scoring system used sex-specific median intake values as cutoffs within the study population. Participants received a score of 1 if their intake was equal to or exceeded the median for beneficial dietary components (vegetables, legumes, nuts and fruits, cereals, and fish) or fell below the median for less favorable components (meat and dairy). Conversely, a score of 0 was assigned if the intake was below the median for beneficial components or above the median for unfavorable components. For fat intake, the MUFA/SFA ratio was used as a criterion, with values above the median assigned a score of 1 and those below the median assigned a score of 0. Due to cultural and religious factors, alcohol consumption was not included in the scoring system, as it is infrequently reported in the Iranian population. The final MD was calculated by summing the scores across all eight components, yielding a total score ranging from 0 (indicating no adherence to the Mediterranean diet) to 8 (reflecting the highest level of adherence).

Statistical analysis

Descriptive statistical methods were utilized to summarize participants' demographic and clinical characteristics, categorized according to quartiles of the MD. The normality of data distribution was assessed using histogram plots and the Kolmogorov–Smirnov test. Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), while categorical variables were presented as percentages. Group comparisons were conducted using one-way analysis of variance (ANOVA) for continuous variables and the Chi-square test for categorical variables, as appropriate.

Logistic regression models were employed to investigate the association between MD adherence and the odds of cardiometabolic risk factors. Adjustments for potential confounders were applied across three models: (1) a crude model with no adjustments, (2) Model 1, adjusted for age and sex, and (3) Model 2, which incorporated additional adjustments for BMI, educational level, physical activity, smoking status, total energy intake, saturated fatty acid intake, and total fiber intake. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 26 (SPSS, Chicago, IL, USA).

Results

A total of 376 participants were initially involved in the study. Two participants were excluded due to incomplete dietary data, and five were excluded due to discrepancies in reporting, either dietary over- or under-reporting. Consequently, our statistical analysis was conducted based on a final sample of 369 participants. The study participants exhibited a mean age of 39.4 ± 10.0 years and a mean BMI of 45.5 ± 6.1. Furthermore, 12.7% of the participants were identified as men.

Table 1 demonstrates the demographic, anthropometric, and lifestyle characteristics of participants stratified by quartiles of adherence to the MD. There was no significant trend observed for age, BMI, or waist circumference across the quartiles (P-trend > 0.4). Physical activity levels improved with higher adherence to the Mediterranean diet score, though not statistically significant (P-trend = 0.46). Diastolic blood pressure showed a significant decrease across quartiles (P = 0.01), while no significant trends were observed for systolic blood pressure, FBS, TG, Chol, LDL, or HDL (P > 0.05).

[DOI: 10.66224/nfsr.13.1.45]

Table 1. Lifestyle and characteristics of participants according to the quartile of Mediterranean diet score

	Q1	Q2	Q3	Q4	P-trend
Age (year)	39.2 ± 10.5	39.2 ± 10.4	39.6 ± 9.1	39.6 ± 9.6	0.98
Men (%)	19 (12.9)	7 (8.6)	12 (19.0)	9 (11.8)	0.31
Body mass index (Kg/m2)	45.0 ± 6.1	45.4 ± 5.9	45.2 ± 7.0	46.5 ± 5.7	0.40
Waist circumference (cm)	116.0 ± 12.9	117.2 ± 12.4	118.8 ± 13.1	118.1 ± 12.8	0.43
Current smoker (%)	36 (24.5)	19 (23.5)	14 (22.2)	24 (31.6)	0.55
Academic education (%)	36 (24.5)	24 (29.6)	24 (38.1)	15 (19.7)	0.41
Physical activity level					
Low	108 (86.4)	54 (83.1)	38 (77.6)	46 (73.0)	
Moderate	11 (8.8)	8 (12.3)	9 (4.1)	14 (22.2)	0.46
High	6 (4.8)	3 (4.6)	2 (4.1)	3 (4.8)	
SBP	124.1 ± 17.2	124.4 ± 16.7	121.6 ± 17.5	124.6 ± 25.2	0.88
DBP	89.0 ± 12.6	85.1 ± 7.1	80.9 ± 12.1	83.5 ± 21.9	0.01
FBS	106.7 ± 23.0	104.6 ± 25.5	107.4 ± 31.4	105.3 ± 29.1	0.90
TG	145.2 ± 62.4	153.3 ± 82.1	163.7 ± 90.8	153.2 ± 83.9	0.44
Chol	193.3 ± 35.7	188.2 ± 37.4	185.4 ± 39.5	191.4 ± 35.0	0.48
HDL	45.4 ± 11.6	44.4 ± 10.4	42.7 ± 8.4	45.8 ± 8.9	0.28
LDL	119.2 ± 29.5	115.1 ± 30.5	116.7 ± 30.2	119.6 ± 26.2	0.70

Abbreviations: FBS: Fasting blood sugar; TG: Triglyceride; HDL: High-density lipoprotein; LDL: Low-density lipoprotein.

Table 2 highlights differences in dietary intake by MD quartiles. Higher adherence to the MD was associated with increased consumption of whole grains, fish, legumes, nuts, fruits, and vegetables ($P < 0.01$). Additionally, participants in the highest quartile showed significantly higher intake of PUFA/SFA ratios, magnesium, and potassium ($P < 0.01$). Conversely, refined grain intake decreased significantly across MD quartiles ($P = 0.01$).

Table 3 represents the multivariable-adjusted ORs (95% CIs) for the odds of cardiometabolic risk factors according to the quartiles of the MD. The multivariable-adjusted analysis revealed a significant inverse association between adherence to the MD and cardiometabolic risk factors among morbidly obese patients. Compared to participants in the lowest quartile of MD (Q1), those in the highest quartile (Q4) had 66% lower odds of high BP (OR = 0.34, 95% CI: 0.16–0.70, P-trend = 0.01). Similarly, adherence to a higher MD was associated with 58% lower odds of low HDL-C (OR = 0.34, 95% CI: 0.16–0.70, P-trend = 0.03). Moreover, the odds of high FBS was significantly lower in Q4 compared to Q1 (OR = 0.42, 95% CI: 0.20–0.87, P-trend = 0.03). However, no significant association was observed between MD adherence and high triglyceride levels (P-trend = 0.62).

Table 2. Dietary intakes of participants according to the Mediterranean diet score

	Q1	Q2	Q3	Q4	P-trend
Total energy intake (kcal)	2566.0 ± 969.2	2828.3 ± 1060.6	2894.1 ± 1035.5	3128.8 ± 1066.4	0.01
Protein (% of energy)	13.9 ± 2.1	14.0 ± 2.4	14.8 ± 2.1	14.6 ± 2.5	0.02
Carbohydrate (% of energy)	59.2 ± 5.8	57.7 ± 6.5	58.1 ± 5.3	58.1 ± 5.8	0.20
Fat (% of energy)	28.7 ± 5.7	30.6 ± 6.5	30.0 ± 5.1	29.7 ± 5.9	0.09
Whole grain (gram per 1000 kcal)	54.2 ± 48.3	54.8 ± 46.9	70.0 ± 42.9	68.8 ± 39.0	0.02
Refined grain (gram per 1000 kcal)	173.8 ± 69.2	173.8 ± 69.2	135.6 ± 56.4	120.9 ± 44.2	0.01
Total dairy (gram per 1000 kcal)	149.7 ± 115.1	124.4 ± 89.1	123.7 ± 71.0	119.5 ± 92.1	0.08
Fish (gram per 1000 kcal)	2.4 ± 2.6	3.3 ± 3.0	3.7 ± 3.4	5.4 ± 6.1	0.01
Legumes (gram per 1000 kcal)	12.6 ± 8.6	15.0 ± 10.3	16.2 ± 10.1	21.3 ± 13.1	0.01
Nuts (gram per 1000 kcal)	2.4 ± 2.3	4.5 ± 6.0	5.1 ± 5.4	5.5 ± 5.4	0.01
Fruits (gram per 1000 kcal)	108.7 ± 66.7	145.8 ± 87.3	152.1 ± 95.3	166.7 ± 89.3	0.01
Vegetables (gram per 1000 kcal)	115.4 ± 62.3	150.0 ± 83.5	155.8 ± 79.2	211.8 ± 128.5	0.01
PUFA/SFA ratio	0.59 ± 0.21	0.70 ± 0.30	0.72 ± 0.23	0.74 ± 0.23	0.01
Calcium (mg per 1000 kcal)	517.0 ± 176.8	527.7 ± 196.6	534.0 ± 177.3	547.2 ± 207.3	0.71
Magnesium (mg per 1000 kcal)	169.1 ± 37.5	179.0 ± 41.4	195.6 ± 35.1	206.7 ± 40.3	0.01
Potassium (mg per 1000 kcal)	1498.5 ± 413.3	1685.4 ± 510.7	1805.7 ± 473.4	1998.3 ± 595.7	0.01
Total dietary fiber (gram per 1000 kcal)	20.3 ± 10.0	21.1 ± 9.5	19.3 ± 6.7	19.8 ± 5.3	0.62

Abbreviations: PUFA: Polyunsaturated fatty acid; SFA: Saturated fatty acid

[DOI: 10.66224/nfsr.13.1.45]

Table 3. Multivariable-adjusted ORs (95% CIs) for the odds of cardiometabolic risk factors according to the quartiles of the Mediterranean diet score

	Q1	Q2	Q3	Q4	P-value for trend*
High Blood pressure					
Median Score	3.0	5.0	6.0	7.0	
Cases/total	75/147	34/81	16/63	22/76	
Crude model	1 (Ref)	0.69 (0.40-1.20)	**0.32 (0.17-0.62)**	**0.39 (0.21-0.70)**	**0.01**
Model 1[a]	1 (Ref)	0.69 (0.39-1.22)	**0.28 (0.14-0.56)**	**0.35 (0.19-0.66)**	**0.01**
Model 2[b]	1 (Ref)	0.68 (0.35-1.31)	**0.33 (0.15-0.72)**	**0.34 (0.16-0.70)**	**0.01**
High FBS					
Median Score	3.0	5.0	6.0	7.0	
Cases/total	85/147	32/81	32/63	33/76	
Crude model	1 (Ref)	**0.47 (0.27-0.82)**	0.75 (0.41-1.36)	**0.56 (0.32-0.98)**	0.06
Model 1	1 (Ref)	**0.45 (0.25-0.81)**	0.70 (0.37-1.29)	**0.52 (0.29-0.93)**	**0.04**
Model 2	1 (Ref)	**0.50 (0.25-0.97)**	0.80 (0.38-1.68)	**0.42 (0.20-0.87)**	**0.03**
Hight TG					
Median Score	3.0	5.0	6.0	7.0	
Cases/total	58/147	31/81	26/63	30/76	
Crude model	1 (Ref)	0.95 (0.54-1.66)	1.07 (0.59-1.96)	1.00 (0.56-1.76)	0.91
Model 1	1 (Ref)	0.96 (0.55-1.68)	1.05 (0.57-1.93)	1.00 (0.57-1.77)	0.93
Model 2	1 (Ref)	0.89 (0.47-1.69)	0.95 (0.48-2.05)	0.80 (0.40-1.59)	0.62
Low HDL					
Median Score	3.0	5.0	6.0	7.0	
Cases/total	105/147	57/81	49/63	45/76	
Crude model	1 (Ref)	0.95 (0.52-1.72)	1.40 (0.70-2.80)	0.58 (0.32-1.03)	0.19
Model 1	1 (Ref)	0.87 (0.47-1.62)	1.60 (0.77-3.32)	0.55 (0.30-1.00)	0.20
Model 2	1 (Ref)	0.78 (0.38-1.57)	1.37 (0.58-3.24)	**0.34 (0.16-0.70)**	0.03

Abbreviations: FBS: Fasting blood sugar; TG: Triglyceride; HDL: High-density lipoprotein.
Obtained by Logistic regression analysis.
* P-trend was obtained using a quartile of dietary exposure as an ordinal variable in the model.
Significant p-values are highlighted in bold.
[a] Model 1: adjusted for age and sex.
[b] Model 2: additionally adjusted for body mass index, educational level, physical activity, smoking, total energy intake, saturated fatty acid intake, and total fiber intake.

[DOI: 10.66224/nfsr.13.1.45]

Discussion

Summary of Principal Findings

This study demonstrated a significant inverse association between adherence to the MD and key cardiometabolic risk factors, including high BP, low HDL-C, and high FBS, in morbidly obese patients preparing for bariatric surgery. These findings reinforce existing evidence supporting the MD as a beneficial dietary pattern for metabolic health. Promoting adherence to the MD may therefore serve as an effective strategy to improve preoperative cardiometabolic status in this high-risk group.

MD Adherence and Blood Pressure Regulation

Our study found that individuals with the highest adherence to the MD had a 66% lower likelihood of hypertension compared to those in the lowest quartile, which is consistent with previous research demonstrating the antihypertensive effects of the MD (14). The MD is rich in fruits, vegetables, whole grains, nuts, and olive oil, which provide essential micronutrients such as potassium and magnesium, known for their vasodilatory and blood pressure-lowering properties (8). Potassium plays a crucial role in reducing blood pressure by counteracting the effects of sodium, modulating vascular tone, and enhancing renal sodium excretion (15). Polyphenols from olive oil and plant-based foods may improve endothelial function, reduce arterial stiffness, and lower oxidative stress, all of which contribute to better blood pressure control (16, 17). Moreover, the MD's emphasis on unsaturated fats, mainly monounsaturated fatty acids (MUFA) from olive oil and polyunsaturated fatty acids (PUFA) from fish, may further support blood pressure reduction by modulating lipid metabolism and reducing systemic inflammation (18). PUFAs, specifically omega-3 fatty acids, have been shown to decrease blood pressure by inhibiting vasoconstriction, reducing platelet aggregation, and improving endothelial function (19). Given that hypertension is a key risk factor for cardiovascular disease (CVD) and surgical complications, promoting MD adherence before bariatric surgery could offer a safe and non-pharmacological approach to improving cardiovascular outcomes (4, 5).

Association between MD and HDL-C Concentrations

Our findings also indicate that adherence to the MD is associated with a 58% lower odds of low HDL-C, aligning with previous studies that have demonstrated the lipid-modulating effects of the MD (20, 21). Elevated HDL-C levels are linked to reduced atherosclerotic risk and better cardiovascular outcomes (17). The MD improves HDL-C through multiple mechanisms. MUFAs and PUFAs from olive oil, fish, and nuts enhance HDL functionality, promoting cholesterol efflux and antioxidant activity (21, 22). Polyphenols in extra virgin olive oil may also increase HDL-C by stimulating paraoxonase-1, an enzyme that protects HDL from oxidation and supports its anti-atherogenic role (23). Additionally, the high intake of dietary fiber from whole grains, legumes, fruits, and vegetables in the MD may play a role in lipid metabolism by reducing cholesterol absorption and promoting bile acid excretion (24). Whole grains, in particular, contain beta-glucans and other soluble fibers that have been shown to lower LDL-C and improve HDL-C concentrations (25). Given that dyslipidemia is a common comorbidity among bariatric surgery candidates, incorporating the MD into preoperative dietary interventions may help optimize lipid profiles and reduce the risk of CVD in this population (4, 5).

Glycemic Control and Fasting Blood Sugar Reduction

Participants with greater MD adherence showed significantly lower odds of high FBS, supporting the role of the MD in glucose regulation. This result is consistent with evidence showing that the MD improves insulin sensitivity and lowers fasting glucose levels (26,27).

The MD's positive effect on glycemic control may be due to its high fiber content, low glycemic index (GI), and abundance of bioactive compounds. Whole grains, legumes, fruits, and vegetables provide dietary fiber that slows gastric emptying, reduces glucose absorption, and improves postprandial glycemia (26, 27). The high intake of complex carbohydrates with a low GI in the MD contributes to a more stable blood glucose profile, reducing insulin demand and improving pancreatic β-cell function (27). Additionally, polyphenols found in olive oil, nuts, and certain fruits have been reported to enhance insulin sensitivity by modulating glucose uptake in peripheral tissues and reducing inflammation in pancreatic β-cells (28).

Moreover, omega-3 fatty acids from fish have been shown to improve insulin sensitivity and reduce hepatic glucose production by modulating adipocyte function and reducing ectopic fat deposition in the liver (29, 30). This mechanism is particularly relevant for morbidly obese individuals, as excessive visceral fat accumulation is a major contributor to insulin resistance and metabolic dysfunction.

Underlying Biological Mechanisms and Integrative Pathways

The beneficial effects of the MD on cardiometabolic health may be explained by several interrelated biological mechanisms. Chronic low-grade inflammation is a key driver of cardiometabolic disorders in obesity (1). The MD's high intake of antioxidants, polyphenols, and unsaturated fats exerts anti-inflammatory effects by reducing pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) (17-19). The MD is rich in antioxidant compounds that counteract oxidative stress, which is implicated in endothelial dysfunction, hypertension, and insulin resistance (19, 20, 29). Olive oil polyphenols, in particular, have been shown to enhance endothelial function and reduce oxidative damage in vascular tissues (19, 31). Emerging evidence suggests that the gut microbiota plays a crucial role in metabolic health (32, 33). The MD promotes a favorable gut microbiome composition by increasing beneficial bacterial strains that produce short-chain fatty acids (SCFAs), which have been linked to improved glucose metabolism and reduced systemic inflammation (32, 33) The MD's emphasis on healthy fats and fiber promotes lipid homeostasis by enhancing hepatic cholesterol clearance, improving HDL-C functionality, and reducing LDL-C oxidation (22, 24, 29, 30).

Clinical Implications for Bariatric Surgery Candidates

Given the high prevalence of metabolic disturbances in bariatric surgery candidates, optimizing dietary patterns before surgery may significantly impact both short-term surgical outcomes and long-term metabolic health. Preoperative adherence to the MD could help reduce perioperative complications, improve weight loss outcomes, and enhance cardiometabolic resilience following surgery. Integrating MD-based dietary interventions into preoperative nutritional counseling may provide a practical and sustainable approach to improving metabolic health in this population.

Strengths and limitations

To our knowledge, this study is the first to examine the relationship between adherence to the MD and the odds of cardiometabolic risk factors in morbidly obese patients preparing for bariatric surgery. We utilized validated and reliable questionnaires to gather nutritional data through face-to-face interviews, ensuring the accuracy of the information collected. Furthermore, all dietary and anthropometric assessments were conducted by highly trained dietitians, minimizing potential errors in data gathering. One of the key strengths of this study is the use of the widely recognized MD, a reliable and reproducible tool that provides a well-established measure of dietary adherence. This makes the MD particularly valuable for clinical and epidemiological research. Another strength of this study is the rigorous methodology used to reduce potential sources of bias. Specifically, selection bias was minimized through predefined eligibility criteria, independent screening, and data verification by multiple reviewers. Moreover, recall bias was addressed by employing validated dietary assessment instruments and conducting structured, interviewer-administered questionnaires, which improved the reliability of participants' dietary reports.

[DOI: 10.66224/nfsr.13.1.45]

However, several limitations must be considered. The cross-sectional nature of the study restricts the ability to draw causal conclusions, and dietary intake was assessed using a FFQ, which is susceptible to recall bias. While the MD is a well-established method, it does have limitations when applied to non-Mediterranean populations. For instance, the exclusion of alcohol from the MD—due to cultural and religious factors in the Iranian population—may limit the generalizability of the findings to regions or populations where alcohol consumption is more common. Additionally, the MD does not account for variations in food preparation, such as the use of unhealthy cooking oils or added sugars, which may influence the health benefits of the Mediterranean diet. The study also lacks an assessment of other potential confounders, such as genetic predispositions, or psychological factors (e.g., depression or stress), all of which could impact metabolic health in bariatric surgery candidates. Moreover, although antihypertensive and antidiabetic medication use was considered in defining high blood pressure and high fasting blood sugar, detailed information on the use of lipid-lowering drugs such as statins was not available, which may have introduced residual confounding. Furthermore, given the cross-sectional design, the possibility of reverse causality cannot be excluded; individuals with healthier lifestyles or better metabolic profiles may be more likely to adhere to the Mediterranean diet, which could partially explain the observed associations. Finally, while the study focuses on a high-risk population of morbidly obese patients, its findings may not be directly applicable to individuals with less severe obesity or those who are not candidates for bariatric surgery. The effects of diet may vary across different levels of obesity, warranting further investigation to assess the generalizability of these results.

Future research should include prospective studies and randomized controlled trials to explore the causal relationship between adherence to the Mediterranean diet and cardiometabolic health in morbidly obese patients. Additionally, assessing the impact of Mediterranean diet adherence on postoperative outcomes, such as long-term weight loss maintenance and improvements in metabolic health, would offer valuable insights that could inform dietary recommendations for this population.

Conclusion

In conclusion, adherence to the Mediterranean diet is significantly associated with lower odds of high BP, low HDL-C, and high FBS in morbidly obese individuals preparing for bariatric surgery. These findings underscore the potential role of the MD as a beneficial dietary strategy for optimizing cardiometabolic health in this high-risk population. Future research should focus on integrating MD-based dietary interventions into preoperative nutritional counseling to enhance both surgical success and long-term metabolic outcomes.

Declarations

Ethics approval and consent to participate: The studies involving humans were approved by the ethics committee at Islamic Azad University, Science and Research Branch (Approval ID: IR.IAU.SRB.Rec.1403.543). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants.

Consent for publication: Not applicable.

Availability of data and materials: The datasets analyzed in the current study are available from the corresponding author on reasonable request.

Financial disclosure

The authors declare no competing interests.

Funding/Support

No financial support was provided in any way for this research.

Author contributions: Overall, SAK and HA, supervised the project and approved the final version of the manuscript to be submitted. SAK designed the research; HA analyzed and interpreted the data; FSH drafted the initial manuscript; and HA critically revised the manuscript. All authors approved the final version of the manuscript submitted for publication.

Acknowledgement

The authors express their appreciation to the participants of the study for their enthusiastic support and to the staff of the involved hospitals for their valuable help.

References

1. Mehrabani J, Ganjifar Z. Overweight and obesity: a brief challenge on prevalence, complications and physical activity among men and women. MOJ Womens Health. 2018;7(1):19-24.
2. Abdelaal M, le Roux CW, Docherty NG. Morbidity and mortality associated with obesity. Ann Transl Med. 2017;5(7):161.
3. Liao J, Yin Y, Zhong J, Chen Y, Chen Y, Wen Y, Cai Z. Bariatric surgery and health outcomes: An umbrella analysis. Frontiers in endocrinology. 2022;13:1016613.
4. Bettini S, Belligoli A, Fabris R, Busetto L. Diet approach before and after bariatric surgery. Reviews in Endocrine and Metabolic Disorders. 2020;21:297-306.
5. Holderbaum MS, Buss C. Dietary management in the immediate preoperative period of bariatric surgery: a national overview: bariatric preoperative diets. Obesity surgery. 2018;28:1688-96.
6. Estruch R, Ros E. The role of the Mediterranean diet on weight loss and obesity-related diseases. Reviews in Endocrine and Metabolic Disorders. 2020;21(3):315-27.

[DOI: 10.66224/nfsr.13.1.45]

7. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. New England Journal of Medicine. 2003;348(26):2599-608.
8. Muscogiuri G, Verde L, Sulu C, Katsiki N, Hassapidou M, Frias-Toral E, et al. Mediterranean diet and obesity-related disorders: what is the evidence? Current obesity reports. 2022;11(4):287-304.
9. Hosseini-Esfahani F, Koochakpoor G, Daneshpour MS, Sedaghati-Khayat B, Mirmiran P, Azizi F. Mediterranean dietary pattern adherence modify the association between FTO genetic variations and obesity phenotypes. Nutrients. 2017;9(10):1064.
10. Warnick GR, Knopp RH, Fitzpatrick V, Branson L. Estimating low-density lipoprotein cholesterol by the Friedewald equation is adequate for classifying patients on the basis of nationally recommended cutpoints. Clin Chem. 1990;36(1):15-9.
11. Eckel RH, Cornier M-A. Update on the NCEP ATP-III emerging cardiometabolic risk factors. BMC medicine. 2014;12:1-9.
12. Esfahani FH, Asghari G, Mirmiran P, Azizi F. Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. J Epidemiol. 2010;20(2):150-8.
13. Asghari G, Rezazadeh A, Hosseini-Esfahani F, Mehrabi Y, Mirmiran P, Azizi F. Reliability, comparative validity and stability of dietary patterns derived from an FFQ in the Tehran Lipid and Glucose Study. Br J Nutr. 2012;108(6):1109-17.
14. Filippou CD, Thomopoulos CG, Kouremeti MM, Sotiropoulou LI, Nihoyannopoulos PI, Tousoulis DM, Tsioufis CP. Mediterranean diet and blood pressure reduction in adults with and without hypertension: A systematic review and meta-analysis of randomized controlled trials. Clin Nutr. 2021;40(5):3191-200.
15. Aburto NJ, Hanson S, Gutierrez H, Hooper L, Elliott P, Cappuccio FP. Effect of increased potassium intake on cardiovascular risk factors and disease: systematic review and meta-analyses. Bmj. 2013;346.
16. Shannon OM, Mendes I, Köchl C, Mazidi M, Ashor AW, Rubele S, et al. Mediterranean diet increases endothelial function in adults: a systematic review and meta-analysis of randomized controlled trials. The Journal of Nutrition. 2020;150(5):1151-9.
17. Yamagata K, Tagami M, Yamori Y. Dietary polyphenols regulate endothelial function and prevent cardiovascular disease. Nutrition. 2015;31(1):28-37.
18. Schwingshackl L, Hoffmann G. Mediterranean dietary pattern, inflammation and endothelial function: a systematic review and meta-analysis of intervention trials. Nutrition, Metabolism and Cardiovascular Diseases. 2014;24(9):929-39.
19. Scoditti E, Capurso C, Capurso A, Massaro M. Vascular effects of the Mediterranean diet—Part II: Role of omega-3 fatty acids and olive oil polyphenols. Vascular pharmacology. 2014;63(3):127-34.
20. Kastorini C-M, Milionis HJ, Esposito K, Giugliano D, Goudevenos JA, Panagiotakos DB. The effect of Mediterranean diet on metabolic syndrome and its components: a meta-analysis of 50 studies and 534,906 individuals. Journal of the American college of cardiology. 2011;57(11):1299-313.
21. Grao-Cruces E, Varela LM, Martin ME, Bermudez B, Montserrat-de la Paz S. High-density lipoproteins and mediterranean diet: A systematic review. Nutrients. 2021;13(3):955.
22. Rondanelli M, Giacosa A, Morazzoni P, Guido D, Grassi M, Morandi G, et al. MediterrAsian diet products that could raise HDL-cholesterol: A systematic review. BioMed Research International. 2016;2016(1):2025687.
23. Zupo R, Castellana F, Crupi P, Desantis A, Rondanelli M, Corbo F, Clodoveo ML. Olive Oil Polyphenols Improve HDL Cholesterol and Promote Maintenance of Lipid Metabolism: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Metabolites. 2023;13(12):1187.
24. Mekki N, Dubois C, Charbonnier M, Cara L, Senft M, Pauli AM, et al. Effects of lowering fat and increasing dietary fiber on fasting and postprandial plasma lipids in hypercholesterolemic subjects consuming a mixed Mediterranean-Western diet. The American Journal of Clinical Nutrition. 1997;66(6):1443-51.
25. de Morais Junior AC, Schincaglia RM, Viana RB, Armet AM, Prado CM, Walter J, Mota JF. The separate effects of whole oats and isolated beta-glucan on lipid profile: A systematic review and meta-analysis of randomized controlled trials. Clinical Nutrition ESPEN. 2023;53:224-37.
26. Biesalski HK. Diabetes preventive components in the Mediterranean diet. European Journal of Nutrition. 2004;43:i26-i30.
27. Esposito K, Maiorino MI, Bellastella G, Chiodini P, Panagiotakos D, Giugliano D. A journey into a Mediterranean diet and type 2 diabetes: a systematic review with meta-analyses. BMJ Open. 2015;5(8):e008222.
28. Guasch-Ferré M, Merino J, Sun Q, Fitó M, Salas-Salvadó J. Dietary polyphenols, Mediterranean diet, prediabetes, and type 2 diabetes: a narrative review of the evidence. Oxidative medicine and cellular longevity. 2017;2017(1):6723931.
29. Vetrani C, Verde L, Colao A, Barrea L, Muscogiuri G. The Mediterranean Diet: effects on insulin resistance and secretion in individuals with overweight or obesity. Nutrients. 2023;15(21):4524.
30. Scorletti E, Byrne CD. Omega-3 fatty acids, hepatic lipid metabolism, and nonalcoholic fatty liver disease. Annual review of nutrition. 2013;33(1):231-48.
31. Manna C, D'Angelo S, Migliardi V, Loffredi E, Mazzoni O, Morrica P, et al. Protective effect of the phenolic fraction from virgin olive oils against oxidative stress in human cells. Journal of agricultural and food chemistry. 2002;50(22):6521-6.
32. Barber TM, Kabisch S, Pfeiffer AF, Weickert MO. The effects of the Mediterranean diet on health and gut microbiota. Nutrients. 2023;15(9):2150.
33. Kimble R, Gouinguenet P, Ashor A, Stewart C, Deighton K, Matu J, et al. Effects of a mediterranean diet on the gut microbiota and microbial metabolites: A systematic review of randomized controlled trials and observational studies. Crit Rev Food Sci Nutr. 2023;63(27):8698-719.

[DOI: 10.66224/nfsr.13.1.45]