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Original Article

The association between dietary profile with practical biochemical parameters in bariatric surgery candidates

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Abstract

Background: The diet of individuals with morbid obesity often is different from the diet of normal weight adults. Among several methods for evaluating dietary intakes, dietary patterns and diet quality indices (Mediterranean Diet score (MDs) and Healthy Eating Index (HEI)) are most informative. The aim of the present study is determination of association between dietary patterns, MDs and HEI with anthropometric and biochemical parameters in individuals with morbid obesity who are candidates of bariatric surgery.

Methods: Participants of present study were adults with morbid obesity who candidate for bariatric surgery and have referred to the surgery clinic of Firoozgar Hospital. Ideal Body Weight and Adjusted Ideal Body Weight were calculated. The dietary data were collected using a Food Frequency Questionnaire (FFQ). Dietary patterns, MDs and HEI were calculated using FFQ data. Anthropometrics and biochemical parameters were assessed. All statistical analyses were done using SPSS. A p-value of <0.05 was considered significant.

Results: HEI and MDs were negatively related to blood iron status. Moreover, these dietary indices were associated with ferritin level. In the case of HEI, this relationship was positive while negative for MDs. A significant correlation was seen between dietary pattern 1 with body mass index (BMI), total cholesterol and iron. Such a correlation was also seen between dietary patter 2 with Albumin. However, no correlation was seen between dietary pattern 3 with any of anthropometric and biochemical parameters.

Conclusion: Finding of present study indicates that regardless of energy intake, diet quality plays a critical role in the metabolic health of body.

Keywords: dietary pattern, diet quality index, Mediterranean Diet score, Healthy Eating Index, Dietary Indices, bariatric surgery, obesity.

Introduction

Obesity as a chronic disease is considered a worldwide health concern at such an alarming pace (1). Considering serious complications and comorbidities of obesity, namely heart disease, cancer, fatty liver diseases, chronic kidney diseases and metabolic syndrome (2-4), there is an urgent need for a long-term treatment rather than intermittent remedies. In such context, bariatric surgery is approved as an effective treatment of severe obesity on a population level (5, 6). While the micronutrient status of patients has been widely examined postoperative (7-9), few are those studies examining preoperative nutritional deficiencies of bariatric surgery candidates (10-13).

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These studies are somehow inconsistent with each other regarding the examined variables and the number of subjects included and they have mostly assessed the micronutrients status rather than dietary patterns. The diet of individuals with morbid obesity is rich in unhealthy food low in nutritional values like refined sugar, white rice, fat, and oil (14), and lack of fruit and vegetables. Since dietary patterns are considered as a means to investigate complex combinations of foods and their synergistic or antagonistic effects (15), they can reveal how dietary determinants affect the etiology of obesity and other chronic diseases (16). Advanced glycation end products (AGEs) are proposed as a dietary factor which has been considered in relation to a wide range of obesity related metabolic disorders (9, 17-20). It has been partially approved that dietary AGEs intake is associated with obesity and accompanied metabolic complications, namely inflammation (17), cardio-metabolic risks (21) and hypertension (19), however it has not been assessed in obese patients prior to bariatric surgery.

To identify the dietary patterns associated with obesity and its correlates, various techniques have been employed. Dietary quality indexes are used to score individuals based on their adherence to dietary guidelines (22), among which Healthy Eating Index-2010 (HEI-2010) and Mediterranean Diet score (MDs) are discussed more recently (23, 24). According to previous studies unhealthy dietary patterns characterized as energy-dense, high-fat, and low-fiber density with a significantly higher risk of obesity (25). The Mediterranean diet has been recognized as a healthy pattern protecting against several chronic diseases (26-28), and likewise more adherence is associated with lower obesity risk (29). However, it was not associated with overweight or obesity in an Iranian adolescent population (24). Not only HEI is a measure of overall diet quality, but it also considers the recommended caloric intake in the scoring rules, as well as markers of energy density (30), so it can be considered as a predictor of obesity.

This study is the first one to assess dietary AGEs intake and dietary patterns and quality in the individuals with morbid obesity who are candidates of bariatric surgery and their association with anthropometric and biochemical parameters.

Methods

Subjects: The present cross-sectional study was performed on 170 adults with morbid obesity that is on a waiting list of bariatric surgery based on an individualized clinical decision plan. Participants aged 20–65 years old, with either BMI≥40 kg/m2 without coexisting medical problems or BMI≥35 kg/m2 and one or more severe obesity-related comorbidities, patients with BMI of 30–34.9 kg/m2 with diabetes or metabolic syndrome were included in the study (31). The study exclusion criteria included having a history of previous bariatric operations or taking multivitamins and minerals.

Ethical approval to conduct the study was obtained from the Iran University of Medical Sciences Ethical Approval Board (Date of approval: 8 October 2018; ethical approval code IR.IUMS.REC 1396.31585). Written informed consent was obtained from all participants.

Biochemical and anthropometric measurements: All patients were assessed to evaluate surgical eligibility by cardiologist, endocrinologist, pulmonologist, and nutritionist.

Blood sample collection and all biochemical analysis were done on the same day at the Firoozgar Hospital Laboratory.

Baseline characteristics of the participants including age and anthropometric were measured. Weight was measured to the nearest 100 g through digital Seca scale 813 (Hamburg, Germany) while the subjects were clothed scantily wearing no shoes. Height was measured to the nearest 0.5 cm, in a standing position with no shoes using a tape meter stadiometer by qualified staff.

Waist circumference (WC) was measured at the level of the umbilicus, and hip circumference was measured over light clothing at the widest girth of the hip. BMI was calculated as weight/height2. Ideal body weight (IBW) and adjusted ideal body weight (AIBW) were calculated using the following equations (32):

IBW (men) = 50+ 0.91 x ((height x100) -152)

IBW (women) = 45 + 0.91 x ((height x100) -152)

AIBW = IBW + 0.25 x (weight - IBW)

Excess body weight was calculated by subtracting adjusted ideal body weight (AIBW) from actual body weight. To minimize the random observer error, the same expert carried out all the measurements for the female and male participants.

Dietary assessment :A 147-item food frequency questionnaire (FFQ) was used to assess typical food intakes over the previous year. The validity of the food frequency questionnaire was previously evaluated by comparing food groups and nutrient values determined from the questionnaire with values estimated from the average of twelve 24-h dietary recall surveys (33).

AGE intake : Since the Iranian Food Composition Table (FCT) does not address information on AGEs content of foods, the published food AGEs database (34, 35) for 549 commonly consumed food items for the Northeastern American multi ethnic urban population was applied to determine dietary AGEs intake of participants. The AGEs values were determine based on kilo-Unit (kU) in 100 g solid food or 100 ml liquid for 116 food items assessed in the FFQ. The amount of AGEs consumption was adjusted for daily energy intake using the nutrient-density method. Energy adjusted AGEs intake was derived using energy density approach by calculating AGEs per 1000 kcal.

Diet Quality Index HEI-2010 : The HEI-2010 is comprised of 12 dietary components, nine adequacy components (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids) with higher scores indicating higher consumption and three moderation components (refined grains, sodium, empty calories) with higher scores indicating lower consumption. This index was defined based on compliance with the 2010 Dietary Guidelines for Americans. The maximum score for each component of adequacy was considered as total fruit (5 points); whole fruit (5 points); total vegetables (5 points); greens and beans (5 points); whole grains (10 points); dairy (10 points); total protein foods (5 points); seafood and plant proteins (5 points); and fatty acids ((PUFAs, MUFAs)/SFAs) (10 points), and for moderation components was defined as refined grains (10 points); sodium (10 points); and empty calories (solid fats, alcoholic beverages, and added sugars) (20 points).

All of the mentioned scores were adjusted for energy (per 1,000 kcal) except for the fatty acid's ratio score. The highest HEI-2010 score is the value of 100 and the higher score represents better diet quality (36).

Med-DQI: The Mediterranean diet quality index (Med-DQI) was computed according to data obtained from FFQ. Seven components (Saturated fatty acids, cholesterol, meat, Olive oil, fish, cereals, Vegetables + fruits) were assessed in this index and a score of 0, 1 or 2 was assigned to the daily intake of each of mentioned component. A total score ranged between 0 and 14 which lower score indicates a high quality of diet and better adherence to the Mediterranean dietary pattern (37).

Dietary patterns : In order to determine dietary patterns, the principal component analysis (PCA) was applied based on dietary information collected from the 18 food groups (Table 1) based on the similarity in their nutrient contents. The Factor scores of the participants were calculated using the sum of multiplying the intake of the standardized food groups by their respective factor loadings on each pattern.

Statistical analysis : Continuous variables are reported as mean ± SD. To test the difference between the mean of age, BMI, biochemical parameters and also dietary intakes of participants across tertiles of dietary patterns and diet quality index, One-Way ANOVA was used. Correlation between anthropometric and biochemical parameters with dietary indices was assessed by Pearson's correlation in cases where the distribution was normal. Spearman correlation test was used where the distribution of the variable was not normal. SPSS (Version 20) software (IBM Corp, Armonk, NY, USA), GraphPad Prism (Version 6) (GraphPad Software, La Jolla, CA, USA), and Microsoft Excel 2010 (Microsoft Office Professional Plus 2010) were used for data analysis. For all statistical tests, p values ≤ 0.05 were considered statistically significant.

Results

Baseline characteristics of subjects present in **Table 1.** The mean age and standard deviation of participants is 36.2±11.07 years. The mean of anthropometric and biochemical parameters of subjects according to tertiles of diet quality indices scores; HEI and MDs depict in **Table 2.** No significant differences in biochemical parameters were seen across diet quality indices scores except for total cholesterol (Q2:207.89±45.54 mg/dl vs. Q3:187.75±39.31 mg/dl, P=0.02) and LDL cholesterol (Q2:128.95±35.78 mg/dl vs. Q3:113.3±31.11 mg/dl, P=0.04) which were significantly lower in the highest HEI tertile compare to second tertile groups. In contrast to HEI, the levels of iron (Q1: 7.32±3.61 mg/dl vs. Q2: 3.49±20 mg/dl vs. Q3: 1.52±1.41 mg/dl, P=0.00) and ferritin (Q1: 92.62±85.8 mg/dl vs. Q2: 59.99±60.35 mg/dl vs. Q3: 53.65±51.58 mg/dl, P=0.005) were significantly higher in the lowest MDs score tertile compare to two other groups.

The mean dietary intakes of study participants across tertiles of diet quality indices scores (HEI and MDs) shows in **Table 3.** The mean energy intake was significantly higher in the lowest tertile of both HEI (Q1: 4391.58±1673.25 kcal/day vs. Q3: 3654.11±1732.54 kcal/day, P=0.04) and MDs (Q1: 5434.84±19.11.94 vs. Q3: 2569.99±709.57, P<0.0001) indices. The intake of PUFA was significantly lower in the highest tertile of MDs while the intake of SFA (Q1: 8.63±2.27% of total energy vs. Q3: 10.15±3.32% of total energy, P=0.01) was significantly higher in the highest tertile of MDs index. However, no such difference was seen for HEI. Total fiber intake was significantly higher in the group with the lowest HEI and MDs. Vitamin B12 intake (Q1: 7.41±5.99% of total energy vs. Q3: 4.71±3.13% of total energy, P=0.01) was also significantly lower in the group with highest MDs.

Table 4 presents the correlation between DQI and anthropometric and biochemical parameters. HEI (r= -0.18, P=0.01) and MDs (r= -0.18, P<0.0001) were significantly negative related with blood iron status. Moreover, these dietary indices were significantly associated with ferritin level. In the case of HEI, this relationship was positive while negative for MDs.

Anthropometric and biochemical parameters of subjects according to tertiles of dietary patterns illustrate in **Table 5.** BMI, total cholesterol, triglyceride (TG) and LDL cholesterol showed significant differences between tertile of dietary pattern 1.

The dietary intake of participants by categories of dietary patterns is shown in **Table 6.** Total fiber intake (Q2: 57.65±31.91 vs. Q3: 82.35±63.91, P=0.02) was significantly higher in the highest tertile of pattern 2 compare to second tertile and protein intake (Q1: 12.06±2.17 vs. Q3: 13.11±2.68, P=0.04) was also significantly higher in highest tertile group of patterns 3 compare to lowest tertile group.

Significant correlation was seen between dietary pattern 1 with BMI (r=-0.17, P=0.02), total cholesterol (r=-0.14, P=0.04) and iron (r=0.25, P=0.00). Such a correlation was also seen between dietary pattern 2 with Albumin (r=-0.16, P=0.03), **Table 7.**

Table 1. Baseline Characteristics of the Participants

Demographics	Mean ± SD
Age (years)	**36.2±11.07**
Weight (kg)	**123.23±20.12**
Height (cm)	**162.15±9.12**
Waist circumference (cm)	**115.18±10.21**
Hip circumference (cm)	**119.35±9.05**
W/H ratio	**0.96±0.35**
Body mass index (kg/m^2)	**46.73±5.99**
Excess weight (kg)	**48.6±12.24**

W/H ratio: waist to hip ratio

Table 2. Anthropometric and Biochemical Parameters According to Tertiles of Diet Quality Indices Score among Patients with Morbid Obesity

	HEI score				MDS			
	1	**2**	**3**	**p-value**	**1**	**2**	**3**	**p-value**
Age (yr)	35.59±9.62	38.6±10.08	38±10.84	0.26	38.32±9.85	37.1±9.9	36.78±10.84	0.7
BMI (kg/m^2)	46.32±6.61	45.95±6.99	44.65±7.68	0.43	46.15±8.6	44.52±5.24	46.11±7.01	0.37
FBS (mg/dl)	111.35±36.1	117.34±50.62	117.46±41.3	0.69	123.46±53.37	111±40.08	111.57±32.31	0.22
TC (mg/dl)	194.24±36.54	207.89±45.54†	187.75±39.31†	**0.02**	202.58±47.44	194.28±39.36	193.19±36.53	0.42
TG (mg/dl)	165.09±99.95	187.44±99.21	155.58±59.5	0.14	178.18±93.57	153.22±60.95	174.8±105.19	0.26
LDL (mg/dl)	118.36±35.88	128.95±35.78†	113.3±31.11†	**0.04**	120.57±40.12	122.11±32.21	118.54±32.02	0.86
HDL (mg/dl)	44.26±9.65	46.86±12.4	47.2±19.36	0.53	47.87±19.51	45.86±11.13	44.49±10.66	0.45
LDL/HDL	2.83±1.11	2.92±1.07	2.64±1.01	0.35	2.77±1.19	2.81±1.03	2.81±0.97	0.97
Iron(mg/dl)	5.04±3.85	3.62±3.28	3.69±3.18	0.053	7.32±3.61$^{**\|}$	3.49±20**‡	1.52±1.41$^{\|\ddagger}$	**0.00**
Ferritin(ng/mL)	50.92±51.26	79.07±81.89	72.49±64.74	0.07	92.62±85.8*§	59.99±60.35*	53.65±51.58§	**0.005**
Transferrin(mg/dl)	280.52±83.07	274.65±58.16	245.36±19.48	0.26	255.87±36.69	275.56±74.99	270.81±64.34	0.63
Alb(g/dl)	4.25±0.39	4.24±0.5	4.97±4.96	0.32	4.22±0.46	5±4.91	4.21±0.4	0.87
HbA1C	6.27±1.42	6.13±1.12	6.12±1.24	0.79	6.45±1.39	5.98±1.32	6.05±0.98	0.09
Vit. B12(fL)	249.12±124.91	265.24±134.17	293.74±257.6	0.43	273.21±243.83	259.64±107.66	276.27±171.45	0.27
Vit.D3	18.15±14.63	18.47±14.11	19.02±14.24	0.94	16.27±13.45	18.76±13.73	20.55±15.14	0.25

* P<0.05, **P<0.001
† P<0.05, ‡P<0.001
§ P<0.05, $^{\|}$P<0.001
HEI: healthy eating index, MDs: Mediterranean diet score, BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, TG: triglyceride, LDL: low-density lipoprotein cholesterol, HDL: high-density lipoprotein cholesterol, Alb: albumin, HbA1c: Hemoglobin A1C
One-way ANOVA

Table 3. Dietary Intake of Patients with Morbid Obesity by Categories of Diet Quality Index

	HEI score				MDS			
	1	**2**	**3**	**p-value**	**1**	**2**	**3**	**p-value**
Dietary quality index Range Mean	<37 45.22	50-56 53.11	>57 61.71	-	<1.22 0.94	1.22-1.83 1.53	>1.85 2.69	-
Energy intake (kcal/d)	4391.58±1673.25§	3655.23±1790.05	3654.11±1732.54§	**0.04**	5434.84±19.11.94$^{**\|}$	3684.28±963.08**‡	2569.99±709.57$^{\|\ddagger}$	**0.000**
Carbohydrate (% of total energy)	56.18±7.36	58.56±7.40	57.19±7.07	0.06	58.25±7.68	57.21±7.79	59.62±6.32	0.48
Protein (% of total energy)	12.08±2.19§	12.68±2.23	13.3±2.68§	**0.03**	12.15±2.23$^{\|}$	12.21±2.39‡	13.79±2.28$^{\|\ddagger}$	**0.00**
Fat (% of total energy)	33.66±8.01	31.59±7.25	32.82±6.59	0.32	32.65±7.44	33.41±7.57	31.87±6.86	0.53
MUFA (% of total energy)	10.95±3.19	1023±2.87	10.75±2.65	0.41	10.24±3.15	11.25±2.88	10.41±2.61	0.13
PUFA (% of total energy)	7.37±2.33	6.54±2.35	7.01±2.03	0.15	6.99±2.56$^{**\|}$	7.56±2.24**‡	6.35±1.75$^{\|\ddagger}$	**0.01**
SFA (% of total energy)	10.09±3.33	9.26±2.69	9.28±2.83	0.24	8.63±2.27§	9.74±3.01	10.15±3.32§	**0.01**
Vitamin D (g/d)	1.95±1.43	2.12±1.91	2.31±1.68	0.57	2.31±1.63	2.01±1.54	2.04±1.85	0.57
Vitamin B12 (g/d)	6.71±5.88	5.27±5.39	5.84±4.15	0.34	7.41±5.99§	5.63±5.62	4.71±3.13§	**0.01**
Total fiber (g/d)	88.81±69.08*§	65.54±36.49*	60.9±29.91§	**0.006**	106.17±61.43$^{**\|}$	62.46±30.29**	46.17±25.74$^{\|}$	**0.00**

* P<0.05, **P<0.001
† P<0.05, ‡P<0.001
§ P<0.05, $^{\|}$P<0.001
HEI: healthy eating index, MDs: Mediterranean diet score, MUFA: mono-unsaturated fatty acid, PUFA: poly-unsaturated fatty acid, SFA: saturated fatty acid
One-way ANOVA

Table 4. Correlation between Diet Quality Index (DQI) and Anthropometric and Biochemical Parameters

	HEI		MDs	
	Pearson	**P-value**	**Pearson**	**P-value**
BMI	-0.13(-0.28- 0.02)	0.08	-0.06(-.021- 0.08)	0.39
Waist circumference (cm)	-0.10(-0.24- 0.07)	0.34	-0.07(-0.19- 0.02)	0.32
Hip circumference (cm)	-0.12(-0.20- 0.02)	0.24	-0.09(-0.24- 0.03)	0.25
FBS (mg/dl)	0.01(-0.14- 0.16)	0.86	-0.04(-0.19- 0.11)	0.53
TC (mg/dl)	-0.08(-0.23- 0.07)	0.27	-0.03(-0.18- 0.11)	0.62
TG (mg/dl)	-0.06(-0.21- 0.09)	0.43	0.05(-0.09- 0.21)	0.49
LDL (mg/dl)	-0.09(-0.25- 0.05)	0.2	0.03(-0.12- 0.18)	0.68
HDL (mg/dl)	0.11(-0.04- 0.25)	0.16	-0.05(-0.21- 0.09)	0.48
LDL/HDL	-0.13(-0.28- 0.01)	0.08	0.03(-0.11- 0.18)	0.62
Iron(mg/dl)	-0.18(-0.32- -0.03)	**0.01**	-0.81(-0.85- -0.75)	**<0.0001**
Ferritin(ng/mL)	0.18(0.02-0.32) *	**0.02**	-0.21(-0.34- -0.05) *	**0.00**
Transferrin(mg/dl)	-0.14(-0.41- 0.14)	0.32	0.019(-0.26- 0.31)	0.89
Alb(g/dl)	0.14(-0.01- 0.29)	0.06	-0.005(-0.15- 0.14)	0.94
Hba1C	-0.08(-0.23- 0.06)	0.26	-0.08(-0.23- 0.06)	0.24
Vit. B12(fL)	0.04(-0.1- 0.19)	0.54	-0.01(-0.16- 0.14)	0.89
Vit. D3	0.03(-0.13- 0.18) *	0.71	0.12(-0.03- 0.27) *	0.11

All of correlations reported as Pearson except for some parameters which are specified by the star (*).
HEI: healthy eating index, MDs: Mediterranean diet score, BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, TG: triglyceride, LDL: low-density lipoprotein cholesterol, HDL: high-density lipoprotein cholesterol, Alb: albumin, HbA1c: Hemoglobin A1C
Pearson and Spearman correlation test

Table 5. Anthropometric and Biochemical Parameters According to Tertiles of Dietary Patterns among Patients with Morbid Obesity

	Pattern 1				Pattern 2				Pattern 3			
	1	**2**	**3**	**p-value**	**1**	**2**	**3**	**p-value**	**1**	**2**	**3**	**p-value**
Age (yr)	35.91±10.61	37.22±10.18	39.039.65	0.26	38.89±10.63	35.03±9.14	38.29±10.44	0.09	36.87±9.54	37.38±10.61	37.92±10.47	0.86
BMI (kg/m^2)	45.75±5.77	47.51±7.35†	43.53±7.49†	**0.01**	46.37±8.85	45.31±6.58	45.11±5.45	0.59	44.88±8.01	45.64±5.78	46.24±7.34	0.59
FBS (mg/dl)	108.61±33.37	124.71±55.13	112.47±35.66	0.11	116.46±40.89	111.75±43.36	117.71±44.78	0.73	110.42±31.81	119.42±46.23	115.96±48.74	0.53
TC (mg/dl)	193.44±37.87	208.01±43.41†	188.45±40.56†	**0.03**	204.63±39.27*	181.96±40.84*†	203.51±40.41†	**0.004**	196.82±41.36	195.77±39.89	197.37±43.31	0.97
TG (mg/dl)	144.87±50.01*	193.12±99.15*	167.89±101.57	**0.01**	180.98±104.79*	145.92±72.44*†	179.41±83.45†	**0.059**	163.29±102.82	165.63±82.02	176.76±81.03	0.69
LDL (mg/dl)	115.23±33.17*	132.84±32.85*†	113.06±35.38†	**0.004**	126.26±34.18*	107.64±31.98*†	127.41±35.07†	**0.003**	121.73±35.01	118.31±34.78	121.21±35.07	0.85
HDL (mg/dl)	47.88±19.88	45.56±11.03	44.83±10.14	0.51	44.91±8.91	43.89±11.55	49.37±19.71	0.09	45.97±11.07	46.77±11.81	45.43±18.88	0.88
LDL/HDL	2.661.06	3.06±1.02	2.68±1.08	0.08	2.95±1.04	2.61±1.06	2.84±1.08	0.23	2.81±1.08	2.68±1.03	2.92±1.07	0.46
Iron(mg/dl)	3.85±2.95	3.95±3.71	4.47±3.72	0.59	4.67±3.95*	3.17±2.81*†	4.44±3.43†	**0.04**	3.74±2.66	3.77±3.74	4.74±3.83	0.21
Ferritin(ng/mL)	57.96±64.21	81.43±77.92	66.27±63.28	0.18	81.96±78.61	58.11±63.41	66.01±63.44	0.17	61.31±63.22	73.63±73.59	70.78±70.61	0.61

Transferrin(mg/dl)	274.58±52.41	259.57±56.71	270.48±69.98	0.77	265.27±36.91	252.66±44.46	280.95±85.56	0.44	251.92±46.23	275.6±58.71	272.36±70.37	0.52
Alb(g/dl)	4.22±0.41	4.19±0.47	5±4.82	0.24	4.89±4.93	4.22±0.42	4.32±0.39	0.41	4.3±0.38	4.23±0.46	4.89±4.89	0.41
Hba1C	6.11±1.03	6.27±1.14	6.11±1.29	0.72	6.03±0.84	6.15±1.36	6.31±1.47	0.52	6.05±1.26	6.32±1.28	6.11±1.22	0.48
Vit. B12(fL)	235.41±98.01	267.72±129.74	305.31±266.08	0.12	248.43±100.07	236.83±91.23†	323.41±277.29†	**0.02**	256.03±174.96	255.51±111.25	297.27±236.49	0.37
Vit. D3	18.32±13.22	18.02±14.04	19.28±15.32	0.88	18.68±13.49	16.57±11.25	20.37±17.09	0.35	17.5±13.6	19.46±14.73	18.64±14.29	0.76

* P<0.05, † P<0.05
BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, TG: triglyceride, LDL: low-density lipoprotein cholesterol, HDL: high-density lipoprotein cholesterol, Alb: albumin, HbA1c: Hemoglobin A1C
One-way ANOVA

Table 6. Dietary Intake of Patients with Morbid Obesity by Categories of Dietary Patterns

	Pattern1				Pattern2				Pattern3			
	1	**2**	**3**	**p**	**1**	**2**	**3**	**p**	**1**	**2**	**3**	**p**
Dietary patterns Range Mean	<-16 -1.18	0.19-3.76 1.66	>47.02 10.71		<-12.35 -2.89	-0.05-2.62 1.07	>32.66 8.64		<-6.32 -1.32	0.01-3.18 1.09	>41.5 9.74	
Energy intake (kcal/d)	3850.77±1337.11	3858.84±2038.55	3951.71±1818.34	0.94	4194.43±2211.56	3470.63±1230.11	4002.29±1619.61	0.07	3742.82±1286.13	3716.51±1743.68	4200.09±2099.81	0.25
Carbohydrate (% of total energy)	56.53±7.53	57.79±7.42	57.72±6.94	0.58	57.53±8.02	56.55±7.27	57.98±6.54	0.56	58.02±7.28	57.25±6.91	56.81±7.72	0.67
Protein (% of total energy)	12.53±2.44	12.66±2.17	12.94±2.63	0.65	12.83±2.45	12.55±2.49	12.77±2.32	0.81	12.06±2.17*	12.97±2.26	13.11±2.68*	**0.04**
Fat (% of total energy)	33.58±7.64	32.21±7.31	32.15±6.93	0.51	32.54±7.92	33.55±7.33	31.83±6.56	0.43	32.71±7.59	32.39±7.07	32.82±7.31	0.94
MUFA (% of total energy)	10.8±2.74	10.56±3.09	10.54±2.91	0.87	11.15±3.12	10.51±3.12	10.26±2.38	0.25	10.36±2.78	10.71±2.96	10.82±2.99	0.73
PUFA (% of total energy)	6.94±2.24	6.96±2.48	7.01±2.05	0.99	7.51±2.64	6.69±2.27	6.73±1.71	0.98	6.88±1.92	6.92±2.31	7.11±2.52	0.68
SFA (% of total energy)	9.78±2.73	9.36±2.99	9.39±3.17	0.71	9.05±2.71	10.17±3.14	9.31±2.94	0.11	9.27±3.02	9.55±2.75	9.71±3.12	0.85
Vitamin D (g/d)	2.26±1.86	1.81±1.29	2.29±1.81	0.24	2.12±1.46	2.01±1.72	2.23±1.84	0.79	1.89±1.29	2.27±1.84	2.21±1.84	045
Vitamin B12 (g/d)	5.37±3.02	5.21±3.75	7.11±7.42	0.09	5.82±3.99	4.82±2.93	7.06±7.32	0.06	5.25±3.62	5.35±2.96	7.11±7.52	0.09
Total fiber (g/d)	66.24±34.11	72.59±52.01	75.26±57.74	0.61	74.24±42.81	57.65±31.91*	82.35±63.91*	**0.02**	64.01±31.06	70.71±51.82	79.35±58.92	0.24

*P<0.05
MUFA: mono-unsaturated fatty acid, PUFA: poly-unsaturated fatty acid, SFA: saturated fatty acid
One-way ANOVA

Table 7. Correlation between Dietary Patterns and Anthropometric and Biochemical Parameters

	Pattern 1		Pattern 2		Pattern 3	
	Pearson	**P-value**	**Pearson**	**P-value**	**Pearson**	**P-value**
BMI	-0.17(-0.32- -0.02)	**0.02**	-0.00(-0.15-0.14)	0.97	-0.02(-0.17-0.13)	0.83
Waist circumference (cm)	-0.12 (-0.32-0.13)	0.17	-0.11(-0.23-0.12)	0.25	-0.06(-0.17-0.05)	0.32
Hip (circumference)	-0.07(-0.13-0.09)	0.21	-0.04(-0.15-0.08)	0.31	-0.04(-0.18-0.05)	0.26
FBS (mg/dl)	-0.01(-0.16-0.13)	0.87	0.01(-0.16-0.14)	0.93	-0.01(-0.16-0.13)	0.88
TC (mg/dl)	-0.14(-0.29-0.00)	**0.04**	-0.04(-0.19-0.11)	0.55	-0.05(-0.21-0.09)	0.51
TG (mg/dl)	0.02(-0.13-0.17)	0.78	-0.00(-0.16-0.14)	0.92	0.02(-0.13-0.16)	0.81
LDL (mg/dl)	-0.11(-0.25-0.03)	0.14	0.02 (-0.13-0.16)	0.82	-0.00(-0.16-0.14)	0.91
HDL (mg/dl)	-0.09(-0.24-0.05)	0.21	0.02(-0.12-0.17)	0.76	-0.08(-0.22-0.07)	0.31
LDL/HDL	-0.03(-0.18-0.12)	0.69	0.01(-0.13-0.16)	0.87	0.06(-0.09-0.21)	0.42
Iron(mg/dl)	0.25(0.1- 0.38)	**0.00**	0.07(-0.08-0.22)	0.35	0.13(-0.02-0.27)	0.11
Ferritin(ng/mL)	0.07(-0.08-0.22) *	0.33	-0.1(-0.25-0.05) *	0.18	0.08(-0.07-0.23) *	0.31
Transferrin(mg/dl)	-0.05(-0.33-0.23)	0.71	0.25(-0.04- 0.5)	0.09	0.19(-0.09-0.45)	0.19
Alb(g/dl)	0.01(-0.13-0.17)	0.81	-0.16(-0.31- -0.01)	**0.03**	0.08(-0.07-0.22)	0.31
Hba1C	-0.02(-0.17-0.13)	0.79	0.09(-0.06-0.23)	0.24	-0.4(-0.19-0.11)	0.53
Vit. B12(fL)	0.14(-0.00-0.28)	0.06	0.04(-0.11-0.19)	0.56	0.07(-0.08-0.22)	0.37
Vit. D3	0.02(-0.13-0.18) *	0.74	0.00(-0.15-0.15) *	0.95	0.07(-0.09-0.22) *	0.38

All of correlations reported as Pearson except for some parameters which are specified by the star (*).
BMI: body mass index, FBS: fasting blood sugar, TC: total cholesterol, TG: triglyceride, LDL: low-density lipoprotein cholesterol, HDL: high-density lipoprotein cholesterol, Alb: albumin, HbA1c: Hemoglobin A1C
Pearson and Spearman correlation test

Discussion

The aim of present study is to evaluate relationship between diet quality indices and dietary pattern of patients who candidate for bariatric surgery and some anthropometric and biochemical parameters.

Anthropometric and Biochemical Parameters and Diet Quality Indices Score : The results from the current study did not show any significant association between diet quality indices scores (HEI and MDS) with the anthropometric parameters among patients with morbid obesity prior to bariatric surgery. However, some research studies have shown relation between overall diet quality abdominal obesity. Surprisingly, higher saturated fat intake was associated with a reduced risk of abdominal obesity in men (38).

The finding regarding the relationship between diet quality and weight status from the literature is not consistent. Several cross-sectional studies are showing a negative relationship between BMI as well as the risk of abdominal obesity and diet quality scores. Conversely, some other researchers reported better diet quality among subjects with higher BMI (39-41). Furthermore, in another study better diet quality was reported in association with lower BMI in only specific age groups (42).

The association between HEI and nutritional biomarkers was investigated by the National Health and Nutrition Examination Survey (NHANES) III (43). They concluded that there is a strong correlation between those biomarkers and the quality and patterns of diet. NHANES-report shows that there is a positive correlation between serum and RBC folate, vitamins C and E, and all carotenoids except lycopene HEI score. Nevertheless, no correlation was observed between cholesterol (total, HDL, and LDL), triglyceride, vitamin D, ferritin, selenium, and total calcium level with HEI score. The results were not consistent and this could be justified by day-to-day variability in the HEI and/or the biomarker concentrations as well as measurement errors that probably would influence the relation between HEI score and disease outcomes as well (43).

However, in another study specific and simple dietary score based on the inherent characteristics of the Mediterranean diet was developed. The results of that study showed that the score was inversely associated with systolic blood pressure, C-reactive protein, fibrinogen, total serum cholesterol, body mass index, and oxidized-LDL concentrations. Differences in genetic predisposition, environmental factors and disease patterns in different ethnicities should be considered while using original MDS. In this regard, considering such differences is important for interpreting the results. Also, develop and promote country-based dietary indices has been suggested (44).

Anthropometric and Biochemical Parameters and Dietary Patterns: Several types of research studied the association between various dietary patterns with health outcomes including obesity and overweight (45). A significant positive association was also shown between urban dietary patterns which contains low fruit and green vegetable, with higher odds of obesity. However, it has been noted that there are some factors such as dietary and lifestyle that play a role in obesity development (46). Similarly, a significant correlation was found between a healthy dietary pattern which characterized by a higher intake of vegetables and fruits, soy products, mushrooms, seaweeds, and fish with lower BMI, percentage body fat, WC in a Japanese population. However, no significant association was seen between seafood and alcohol dietary pattern with any of body measurements (47).

The analysis of the association between dietary patterns and BMI revealed that more unhealthy diet pattern is more predictive of higher BMI and conversely, the more prudent dietary pattern is related with lower BMI. It suggests that diet quality in addition to its quantity is also important in determining food consumption consequences regarding weight gain and obesity development (48-50).

Similar to the most results from the literature, a significant association between dietary pattern 1 and BMI was also seen in our study. However, somehow inconsistency regarding the association between dietary patterns and obesity-related measurements; specially BMI and WC or obesity prevalence among the studies that have suggested different methods of analyses (45, 51).

The beneficial effect of the Mediterranean diet on HbA1c, FBG, lipid levels, cardiovascular risk, and increased LDL-cholesterol, HDL-cholesterol levels as well as triglycerides levels, has been shown in the previous meta-analysis study. In the meta-analysis study, authors concluded that glycemic control, cardiovascular risk, and weight loss could improve in diabetic patients due to the Mediterranean diet which is rich in monounsaturated fatty acids, vegetables, fruits, legumes, nuts, and whole grains (52). Consistent with the literature, in our study, we also found a significant association between dietary pattern with total cholesterol and serum iron. Although we did not find significant association between dietary intakes with categories of dietary pattern in our study except for protein and total fiber intake.

The cross-sectional design of present study does not provide evidence of a causal relationship regarding obesity. FFQ may have an error in estimating food intake due to reliance on memory. However, FFQ can better represent actual dietary intakes than a 24-h food recall because it cannot reflect daily variation of diet. Moreover, the lack of standardization of methodologies that makes it difficult to compare studies and to evaluate the overall diet of the selected population, using self- reported dietary data and no specific differentiation of specific foods and food groups are major limitations of the present study.

Conclusion

Diet quality indices scores were not statistically associated with anthropometric parameters in the present population. However, as HEI increased, serum total cholesterol and LDL-cholesterol decreased and also serum iron and ferritin were high in the lowest tertile of MDs. Moreover, we found a significant association between dietary patterns with BMI, total cholesterol, iron and serum albumin. These finding indicate that regardless of energy intake, diet quality plays a critical role in the metabolic health of body in the obese persons.

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Ethical Approval Statement:

The study was conducted according to the Declaration of Helsinki and study protocol was approved by the ethics committee of the Iran University of Medical Sciences number IR.IUMS.REC 1396-31585.

Informed Consent Statement:

Informed written consents were obtained from all participants.

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