

Association of Diet Quality and Food Insecurity with Metabolic Syndrome in Obese Adults

Abstract

Background: The link between diet quality, food insecurity (FI), and metabolic syndrome (MetS) remains unclear in obese adults. The aim of this study was to examine the association of diet quality and FI with MetS in obese Iranian adults. **Methods:** This cross-sectional study was conducted on 300 obese adults. Dietary intake was assessed using a validated 168-item food frequency questionnaire. Diet quality and FI were measured using the Diet Quality Index-International (DQI-I) and an adapted USDA2000 household food security status questionnaire, respectively. MetS was defined according to the International Diabetes Federation diagnostic criteria. Association was determined using logistic regression analysis adjusting for potential confounders. **Results:** MetS subjects had lower DQI-I score than subjects without MetS (67.5 ± 8.7 vs 71.5 ± 7.4 , $P = 0.05$). The prevalence of food insecurity was 48.6% (95% confidence interval (CI): 41.2, 56.1) in MetS subjects and 39.4% (95% CI: 29.4, 49.9) in subjects without MetS. After adjustment, participants in the fourth quartile of DQI-I score had 70% lower odds of MetS (Adjusted odds ratio [AOR], 0.3; 95% CI: 0.1–0.7), 70% lower odds of hypertriglyceridemia (AOR, 0.3; 95% CI: 0.2–0.7) and 60% lower risk of reduced high-density lipoprotein [HDL] (AOR, 0.4; 95% CI: 0.2–0.9) compared with the first quartile. Obese food insecure adults had 60% higher odds of high blood pressure (AOR, 1.6; 95% CI: 1.0–2.6) and 70% higher odds of hypertriglyceridemia (AOR, 1.7; 95% CI: 1.0–2.8) compared with food-secure obese adults. There was no statistically significant interaction observed between DQI-I and food insecurity on MetS. **Conclusions:** Lower DQI-I score and food insecurity were associated with an increased risk of MetS and some features such as hypertriglyceridemia, reduced HDL, and high blood pressure in obese Iranian adults.

Keywords: Diet quality, food security, metabolic syndrome, obesity

Introduction

Metabolic syndrome (MetS) is a major public health concern, and its prevalence in the world is estimated to be approximately 3.3% of the whole population and 29.2% of the obese population.^[1] According to the latest International Diabetes Federation (IDF) criteria, the prevalence of MetS in Iran was 34%.^[2] MetS is a physiological process that increases the risk of cardiovascular diseases (CVD), diabetes, and all-cause mortality due to metabolic dysfunction.^[3] Moreover, the risk of MetS and diabetes have increased five-fold in obese people compared with normal-weight people.^[4] Although there is some evidence to suggest that diet and lifestyle modification can prevent and reduce the risk of metabolic disorders,^[5,6] the relationship between diet quality and components of MetS is inconsistent.^[7,8]

Food insecurity (FI) happens when people are physically or economically unable to obtain and consume nutritionally adequate and safe foods or have uncertainty in their ability to acquire acceptable foods in socially and culturally acceptable ways.^[9] Food insecurity tended to systematically drive increases in the proportion of individuals consuming a poor-quality diet and low-intake levels of essential nutrients.^[10] On the other hand, diet quality, which includes the intake of a healthy, balanced, and nutritious diet is also important to reach optimal health.^[11] Therefore, the concept of food insecurity and diet quality are interrelated, i.e., food insecurity includes the components of insufficient food quantity and quality, feelings of deprivation, and disrupted eating, and so it is inversely associated with higher levels of diet quality.^[12]

Diet quality indices represent a broader picture of food and nutrient consumption,

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Access this article online

Website:
www.ijpvmjournal.net/www.ijpvm.ir

DOI:
10.4103/ijpvm.IJPVM_191_19

Quick Response Code:



How to cite this article: Abdurahman A, Bule M, Fallahyekt M, Abshirini M, Azadbakht L, Qorbani M, et al. Association of diet quality and food insecurity with metabolic syndrome in obese adults. *Int J Prev Med* 2021;12:138.

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therefore, measurement of overall diet quality is used as an alternative method to assess diet-disease relations.^[13] In this regards, the Diet Quality Index-International (DQI-I) developed by Kim *et al.*,^[14] is a sensitive tool to assess overall diet quality. The DQI-I represent dietary patterns that incorporate both nutrient and food perspectives of the diet in the assessment, providing a means which better describes the diversity of consumption. It also takes into account adequacy, moderation, variety, and balance of individuals' diets and gives each factor an individual score.^[14] Thus, this feature makes DQI-I more preferable over measurements of individual nutrients.^[15]

A number of studies have documented the association of diet quality indices and/or adherence to a healthy diet with reduced risk of metabolic abnormality, in addition to modification of cardiovascular risk factors and decreased inflammation and improved endothelial function.^[16,17] Besides, earlier studies have also indicated that food insecurity and an unhealthy dietary pattern has been separately associated with MetS and its feature^[18-20] but the association of food insecurity and DQI-I score with MetS in obese Iranian subjects has been not yet studied.

This research focuses mainly on the importance of food security status and diet quality as a modifiable risk factor for MetS. Therefore, in the current study, we aimed to explore the association of diet quality and food insecurity with respect to MetS and its feature in obese Iranian adults. Moreover, it assessed potential interaction between DQI-I and food insecurity on MetS. Thus, it can provide direction on population-level interventions. Moreover, it will help policymakers to address the availability and accessibility of high-quality and healthy diet for the vulnerable population.

Methods

A total of 300 subjects aged from 19 to 59 years, took part in this cross-sectional study from July to October 2017. The study population comprised of individuals from public health centers across the regions of south Tehran, using community-based sampling according to stratified random sampling. Obese persons were randomly selected with a probability proportional to their population from a sampling frame of a telephone directory database found at the nearby health center. Later, study participants were recruited through a phone call to come to the nearby cluster. Subjects were chosen based on the following inclusion criteria: aged 19–59 years, had a body mass index (BMI) of ≥ 30 kg/m², and lived in the area for 6 months and more. In the present study, out of the 300 participants with valid dietary data, 23 participants (less than 8%) with missing data for fasting blood glucose (FBG), high-density lipoprotein (HDL), and triglyceride (TG) were excluded listwise from regression analyses.

The sample size was determined based on WHO estimated prevalence of obesity in adults of Iran,^[2] which was 26.1%.

Thus, using the formula for estimation of single proportion; $n = (Z^2 \times P(1 - P))/d^2$, the total sample was ~300 obese people.

All procedures performed in the studies involving human participants were in accordance with the ethical standards of the Ethical Committee of Tehran University of Medical Sciences (Approval Number IR.TUMS.VCR.REC.1396.2157). Informed consent was obtained from all individual participants included in the study.

Dietary assessment

Dietary intake was assessed by a valid and reliable semiquantitative food frequency questionnaire (FFQ) with 168 items. Its reliability and validity had been confirmed previously.^[21] The FFQ involved a list of foods and standard serving size for each item. The questionnaires were administered by trained dietitians. Nutritionist IV software modified for Iranian foods was used for the nutrient analysis of the diets. The DQI-I was calculated according to the method described by Kim *et al.*^[14] Based on this method, four major aspects of the diet are assessed in the DQI-I, namely, variety, adequacy, moderation, and overall balance. The variety was evaluated by two components as follows: “between food groups” (0–15 points) and “within protein sources group” (0–5 points). Intake of a half serving from protein sources presented the maximum score for the “within protein group”. Adequacy assesses the fruit, vegetable, and grain group, protein, fiber, calcium, iron, and vitamin C intakes (40 scores). Moderation assessed based on total fat, saturated fat, cholesterol, sodium, and empty calorie foods (30 scores). Sodium scored based on the distribution of subject's intake. Subjects who consumed sodium less than the 15th and over than 85th percentile had 6 and 0 points, respectively. The balance means the balance of micronutrient distribution in diet and fatty acid ratio (10 points). The total DQI-I score ranged from 0 to 100, with a higher score represents better diet quality. The level of intake that defines the highest score for the adequacy of iron, calcium, and vitamin C was derived from the dietary reference intakes (DRI),^[22] which vary by age and gender.

Food security assessment

Food security was measured using the 18-item USDA household food security status (HFSS) questionnaire adapted for Iran.^[23] Food insecurity was determined based on affirmative responses to either of the “food sufficiency questions” which asked whether the household, in the past 12 months, SOMETIMES did not have enough to eat or OFTEN did not have enough to eat. Food security status was classified as (1) food secure: access at all times in the previous year to enough food for an active, healthy life for all household members; (2) food insecure: any household member had compromises in quality and/or quantity of food consumed which may have disrupted eating patterns.

Assessment of anthropometric and biochemical variable

Bodyweight was measured using a scale (Seca, Hamburg, Germany) with 0.5 kg accuracy without shoes and light clothing. Height was measured to the nearest 0.5 cm by using a stadiometer and the stretch-stature method without shoes. BMI was calculated by dividing weight (kg) by height² (m). Waist circumference (WC) was measured by using a nonstretch tape measure, at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Measurement was taken to the nearest 0.1 cm. To avoid measurement error, all data were taken by trained dietitians.

In the morning, venous blood samples were collected after 12-hour overnight fasting following standard chemical procedures. FBG was measured using a modified hexokinase enzymatic method. HDL and TG were measured using a Hitachi 704 analyzer (Boehringer-Mannheim Diagnostics). Blood pressure was measured using a digital sphygmomanometer (OMRON HEM-780, Osaka, Japan) at the right arm twice in the seated position, and the mean values were used in all analyses. Physical activity level was also evaluated by the validated long form of the International Physical Activity Questionnaire (IPAQ-L).^[24]

Definition of metabolic syndrome (MetS)

MetS was defined according to International Diabetes Federation (IDF) diagnostic criteria,^[25] which included abdominal obesity (waist circumference ≥ 94 cm for men or ≥ 80 cm for women), plus two or more of the following: (1) reduced HDL-c (< 40 mg/dL for men and < 50 mg/dL for women, or specific treatment for this lipid abnormality), (2) hypertriglyceridemia (triglyceride level ≥ 150 mg/dL, or specific treatment for this lipid abnormality), (3) raised BP ($\geq 130/85$ mmHg or treatment of previously diagnosed hypertension), or (4) raised fasting plasma glucose (≥ 100 mg/dL or previously diagnosed type 2 diabetes).

Statistical analyses

Normal distribution of continuous variables was checked by Shapiro-Wilk's test. Categorical and continuous variables were presented as a number (percentage) and mean (standard deviation [SD]), respectively. Association of categorical variables with MetS were assessed using χ^2 test. The ANOVA test was used to compare a continuous variable with normal distributions across MetS categories followed by Tukey's multiple comparisons test. The Kruskal-Wallis test, the non-parametric test that is equivalent to the one-way ANOVA, was used. In addition, the linear association of DQI-I quartile and HFI with continuous variables was assessed using ANOVA test of linearity. Tukey *post hoc* test was used to determine statistically significant pairwise differences between quartiles of DQI-I. Multinomial logistic regression models were applied to find determinates of outcome variables (MetS) using

univariate and multivariable models after adjustment for age, sex, education status, smoking status, daily energy intake, physical activity level, and body mass index. In the multivariable model, we included those variables that were significantly associated with the outcome variables at the $P \leq 0.20$ level in the univariate model. Association between independent variables with MetS was assessed using binary logistic regression. Results of binary logistic regression were presented as odds ratios (OR) with 95% confidence intervals (CI). Quartile of DQI-I was considered as a categorical variable and compared the fourth quartile with the first quartile in all analysis. P values < 0.05 was considered as statistically significant. All analyses were performed using STATA (release 11.2 for Windows, Stata Corp LP).

Results

Table 1 summarizes the basic characteristics of study participants by metabolic syndrome status. The mean \pm SD age of 300 subjects was 43.4 ± 10.9 years (range 19–59 years), and 84.1% were female. Within the sample, 60.1% (183/277) of subjects had MetS. Diet quality assessment from the DQI-I scores ranged from 43 to 88 with a mean of 69.1 ± 8.3 . The highest score was for adequacy, followed by variety and moderation. The lowest score was for overall balance. Of interest, MetS subjects had lower DQI-I score and lower score for adequacy than subjects without MetS [$(67.5 \pm 8.7$ vs 71.5 ± 7.4 , $P = 0.05$) and $(32.5 \pm 3.6$ vs 35.5 ± 3.5 , $P = 0.03$), respectively]. There was no significant difference in food security status between obese subjects with MetS and without MetS subjects.

Dietary intakes of obese participants by DQI-I score quartiles and food security status are shown in Table 2. Participants with the highest scores of DQI-I tended to have higher intakes of carbohydrate, protein, and total fiber. However, participants with the highest scores of DQI-I tended to have lower intakes of total fat, saturated fat, monounsaturated fatty acid (MUFA), and polyunsaturated fatty acid (PUFA). On the other hand, compared to participants in the food-secure category, those participants in the food-insecure category consumed less energy, carbohydrate, protein, total fiber, total fat, saturated fat, MUFA, and PUFA.

Metabolic risk factors by DQI-I quartile categories and food security status in obese participants are shown in Table 3. *Post hoc* pair-wise comparisons between Q1 and Q4 showed a higher DQI-I was associated with low levels of fasting blood glucose and diastolic blood pressure. Importantly, the prevalence of MetS was significantly higher in subjects with low scores of DQI-I than those with higher scores (82.7% vs. 63.9%, $P = 0.002$). With respect to individual components of MetS, the prevalence of hypertriglyceridemia was significantly higher in participants with lower scores of DQI-I than those with higher scores;

Table 1: Characteristics of obese participants by metabolic syndrome

Variables	Overall	Metabolic syndrome		P
		Yes (n=183)	No (n=94)	
Sex (Female), %	84.1	86.3	79.8	0.16
Age, years	43.4±10.9	43.9±11.2	42.5±10.3	0.31
Education (≥high school), %	70.4	65.6	78.7	0.02
Current smokers, %	11.9	10.4	14.9	0.55
Energy (kcal)	2596.3±737.1	2564.8±739.1	2657.7±733.4	0.32
BMI (kg/m ²)	34.1±3.8	34.1±3.8	34.0±3.8	0.87
WC (cm)	102.6±11.9	103.9±10.9	99.8±13.2	0.01
High WC, %	95.3	100	86.2	<0.001
SBP (mmHg)	123.1±14.7	126.1±15.6	117.4±10.9	<0.001
Raised SBP, %	65.3	54.6	86.2	<0.001
DBP (mmHg)	78.3±12.1	79.6±13.3	75.6±8.8	0.01
Raised DBP, %	77.6	71.0	90.4	<0.001
HTN, %	48.7	63.9	19.1	<0.001
TG (mg/dL)	139.8±1.6	154.5±1.6	114.4±1.4	<0.001
Raised TG, %	49.5	64.5	20.2	<0.001
FBG (mg/dL)	102.5±1.3	107.8±1.3	93.7±1.2	<0.001
Raised FBG, %	46.2	61.2	17.0	<0.001
HDL (mg/dL)	47.3±1.3	45.6±1.3	50.8±1.3	<0.001
Reduced HDL, %	61.0	71.0	41.5	<0.001
DQI-I score	69.1±8.3	67.5±8.7	71.5±7.4	0.05
Variety	15.5±3.0	15.6±3.2	15.4±2.8	0.66
Adequacy	34.0±3.5	32.5±3.6	35.5±3.5	0.03
Moderation	15.2±5.6	14.8±6.0	15.5±5.3	0.34
Overall balance	4.8±2.5	4.5±2.6	5.1±2.5	0.09
Physical Activity Level, %				0.57
Low PA	58.5	59.0	57.5	
Moderate PA	37.9	36.6	40.4	
High PA	3.6	4.4	2.1	
Food security status				
Food Insecure, %	45.5	48.6	39.4	0.14

Group difference by independent *t*-test for continuous variables and Chi-square or Fisher exact test for categorical variables, Data were expressed as mean±SD for continuous variables and number (%) for categorical variables. BMI: Body mass index, WC: waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HTN: Hypertension, TG: Triglyceride, HDL: High-density lipoprotein, FBG: Fasting blood glucose, DQI-I: Diet Quality Index-International

Table 2: Dietary intakes of obese participants by diet quality index international score quartiles and food security status

Intake	DQI-I quartile categories			Food Security status		
	1Q (n=75) <65	4Q (n=61) >77	P	Food secure (n=151)	Food insecure (n=126)	P
Energy (kcal)	2491.3 (2157.8-2841.3)	2367.7 (1963.5-3075.6)	0.68	2787.7 (2226.8-3488.0)	2292.2 (1941.1-2823.5)	<0.001
CHO (g)	292.1 (244.1-335.3)	350.4 (285.3-448.8)	<0.001	352.7 (288.9-441.2)	300.9 (255.8-364.5)	<0.001
Protein (g)	72.6 (59.9-81.3)	87.8 (67.0-103.6)	<0.001	85.2 (70.6-103.2)	77.9 (66.8-89.5)	0.001
Total Fat (g)	121.7 (91.2-139.6)	72.4 (61.6-106.1)	<0.001	118.3 (83.3-148.2)	89.9 (66.5-123.0)	<0.001
Total Fiber (g)	41.9 (28.5-57.0)	46.9 (36.9-67.2)	0.01	52.3 (35.2-71.3)	40.9 (34.3-54.2)	<0.001
SFA (g)	31.3 (24.2-45.1)	22.3 (16.7-33.8)	0.002	32.4 (22.8-46.7)	23.8 (18.5-38.2)	<0.001
MUFA (g)	43.4 (33.1-50.1)	23.3 (16.9-38.0)	<0.001	42.9 (25.4-52.7)	32.4 (19.2-43.1)	<0.001
PUFA (g)	28.3 (21.9-34.4)	14.1 (9.4-22.2)	<0.001	26.8 (15.6-35.8)	19.1 (11.7-28.4)	<0.001

CHO: Carbohydrate, SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid, Q: quartile. DQI-I: Diet quality index international. The median and interquartile range (IQR) for continuous variables. *P* values were obtained by Kruskal-Wallis rank test

however, the prevalence of raised fasting glucose and blood pressure and reduced HDL showed no significant

difference across quartiles of DQI-I scores. Conversely, compared to subjects in the food secure category, those in

the food insecure category had significantly higher serum levels of triglycerides and fasting blood glucose ($P = 0.02$ and $P = 0.002$, respectively). In addition, the prevalence of raised blood pressure, fasting glucose, and triglycerides was significantly higher in the food insecure participants than that food secure ($P = 0.003$, $P = 0.03$, and $P = 0.01$, respectively); however, the prevalence of MetS and reduced HDL showed no significant difference between the groups.

The logistic regression adjusted odds ratios (ORs) for the association of quartiles of DQI-I score and food security status with components of MetS is shown in Table 4. After adjustment for age, sex, education status, smoking status, daily energy intake, and body mass index, we found, those in the fourth quartile of DQI-I score had reduced odds of MetS compared with the first quartile. In addition, compared with the first quartile (poor diet quality), those in the fourth quartile of DQI-I score had reduced odds of hypertriglyceridemia and reduced HDL. Consequently, in comparison to food-secure individuals, those food insecure

individuals had higher odds of high blood pressure and hypertriglyceridemia. However, no significant association was noted with quartiles of DQI-I score and food security status with other components of MetS. Moreover, the interaction analyses revealed that there was no statistically significant interaction observed between DQI-I and food insecurity on MetS (results not shown).

Discussion

In the present cross-sectional study, we provide, for the first time, evidence that DQI-I scores and household food insecurity was significantly associated with MetS as well as those with components in obese adults. Our results indicated that higher DQI-I score was associated with decreased risk of MetS, hypertriglyceridemia, and reduced HDL. Furthermore, food insecurity was associated with an increased risk of high blood pressure and hypertriglyceridemia in obese Iranian adults. However, there was no statistically significant interaction between DQI-I and food insecurity on MetS. These findings indicate

Table 3: Metabolic risk factors by diet quality index international quartile categories and food security status in obese participants

Risk factors	DQI-I quartile categories			Food security status		P*
	1Q (n=75) <65	4Q (n=61) >77	P: Q1 vs Q4**	Food secure (n=151)	Food insecure (n=126)	
WC (cm)	102.8±11.6	102.1±12.2	0.92	103.5±12.6	102.7±11.5	0.54
SBP (mmHg)	124.6±17.4	118.7±13.5	0.13	121.9±14.3	124.2±15.7	0.19
DBP (mmHg)	79.9±15.6	74.6±8.1	0.07	78.3±11.8	78.1±12.2	0.92
FBG (mg/dL)	112.2±1.4	98.3±1.1	0.01	98.9±1.2	108.2±1.3	0.002
TG (mg/dL)	159.0±1.6	137.9±1.6	0.32	132.1±1.5	150.2±1.6	0.02
HDL (mg/dL)	44.8±1.2	49.4±1.4	0.19	46.6±1.2	48.2±1.3	0.30
MetS Components			P*			P*
MetS, %	82.7	63.9	0.002	62.2	70.6	0.14
Raised BP, %	49.4	45.9	0.75	41.1	58.3	0.003
Raised FBG, %	53.3	44.0	0.41	40.4	53.2	0.03
Raised TG, %	60.0	55.7	0.01	42.4	57.9	0.01
Reduced HDL, %	70.7	57.4	0.16	64.9	56.3	0.15

Data are expressed as mean±SD. P values* obtained by Chi-square test for categorical variables and ANOVA test for continuous variables. P: Q1 vs Q4** represents the P value for the difference between DQI-I quartiles 4 and 1 determined by post hoc test

Table 4: Logistic regression adjusted odds of components of the metabolic syndrome according to diet quality index international score quartiles and food security status in obese participants

Components of MetS	DQI-I quartile categories				P trend**	Food security status		P
	OR (95%CI)					OR (95%CI)		
	1Q (n=75)	2Q (n=66)	3Q (n=75)	4Q (n=61)		Food secure	Food insecure	
MetS	Ref.	0.3 (0.1-0.7)*	0.2 (0.1-0.4)*	0.3 (0.1-0.7)*	0.002	Ref.	1.4 (0.8-2.4)	0.22
Raised BP	Ref.	0.9 (0.4-1.7)	1.1 (0.6-2.2)	0.8 (0.4-1.6)	0.82	Ref.	1.6 (1.0-2.6)*	0.05
Raised FBG	Ref.	0.7 (0.4-1.5)	0.6 (0.3-1.2)	0.5 (0.2-1.0)	0.06	Ref.	1.5 (0.9-2.5)	0.11
Raised TG	Ref.	0.6 (0.3-1.2)	0.8 (0.4-1.7)	0.3 (0.2-0.7)*	0.24	Ref.	1.7 (1.0-2.8)*	0.04
Reduced HDL	Ref.	0.6 (0.3-1.2)	0.4 (0.2-0.7)*	0.4 (0.2-0.9)*	0.02	Ref.	0.9 (0.5-1.6)	0.86

*Significant association ($P < 0.05$). **DQI-I quartile considered as a continuous variable and determined by linear regression models. BP: Blood pressure, DQI-I: diet quality index international, FBG: Fasting blood glucose, HDL: High-density lipoprotein, TG: Triglyceride, - Quartile, MetS: Metabolic syndrome. Adjusted for age, sex, education status, smoking status, daily energy intake (kcal), body mass index, and physical activity level. DQI-I quartiles considered as a categorical variable

that food insecurity and poor diet quality could be risk factors in the pathogenesis of MetS.

In the present study, obese adults demonstrated a substantially higher mean DQI-I score, i.e., 69.1% of the total score, higher than the mean scores reported in the China^[26] and South Africa^[27] studies. The mean DQI-I score in MetS subjects was 67.5% of the total score, which is almost similar to the mean score observed in Korea.^[28] Based on studies by Kim *et al.*,^[14] criteria scores above 60% indicated a good quality diet. The highest scores in the present study were for adequacy and variety, and lower scores for moderation and overall balance, the same result was also found in a study from southern Spain,^[29] and these high scores may be attributable to higher consumption of fruits and vegetables, and legumes by this group of population. The results of moderation and overall balance seemed to reflect the current obesity trends, by which over-nutrition, which is lack of moderation, is the predominant nutrition problem in the world. The dietary adequacy component of the DQI-I categorize individuals' based on their consumption of foods and nutrients on the bases of a healthy diet, such as fruits, vegetables, grains, dietary fiber, protein, iron, calcium, and vitamin C, while the dietary variety component scores evaluate the overall variety and variability within protein sources, and this component assess the consumption of diversified food from the five food groups.^[14] Therefore, it is possible to use the DQI-I used in this study to evaluate the dietary quality of obese people and to use it as basic data for nutrition education.

Our results showed that those in the highest quartile of DQI-I score had reduced odds of MetS, hypertriglyceridemia, and reduced HDL compared to the first quartile. Nevertheless, higher DQI-I was associated with low levels of fasting blood glucose and diastolic blood pressure. Moreover, the prevalence of MetS and raised TG was significantly higher in subjects with low scores of DQI-I than those with higher scores. Although there is no study which compared the association of DQI-I score with MetS and its components in obese subjects, the study conducted by Gregory *et al.*,^[30] showed DQI-I score was positively associated with BMI but not with the metabolic syndrome or its components. Similarly, a study conducted by Alkerawi *et al.*^[31] showed an inverse correlation of DQI-I with the only HDL. Zamora *et al.*^[32] also indicated that higher DQI scores were associated with HDL cholesterol and blood pressure. This contrast of results may be explained due to restricting our sample in this study to only obese adults. Therefore, the results of the present study suggest that adherence to a higher diet quality measured by DQI-I could inhibit the progress of metabolic risk factors such as hypertriglyceridemia and reduced HDL in obese subjects. Earlier studies also suggest that adherence to a specific dietary pattern based on dietary recommendation may be more beneficial for the prevention of the MetS and its complications.^[33]

This study also showed that food insecurity was not significantly associated with the odds of MetS but only with some of its component i.e., high blood pressure and raised triglycerides. Food insecure obese adults had higher odds of high blood pressure and hypertriglyceridemia compared with food-secure counterparts. Moreover, food-insecure obese adults had significantly higher serum levels of triglycerides and fasting blood glucose than the food secure group. In addition, the prevalence of raised blood pressure, fasting blood glucose, and triglycerides were significantly higher in the food insecure participants than those food secure groups. However, previous studies examined the relationship between food insecure and MetS revealed that food-insecure adults had increased odds of MetS compared with those who were food secure.^[20] The lack of association in our study between food insecurity and MetS may be explained partly by the difference in the population included in our study, i.e., only obese adults compared with Parker *et al.*^[20] Nevertheless, it is important to highlight that regardless of food security status, obese people have an increased metabolic risk. It can be assumed that low socioeconomic status and food insecurity could lead to decreased diet quality and increased consumption of energy-dense foods, i.e., refined grains and trans fat or high saturated fats.^[34,35] It should be emphasized that these diets could lead to obesity, thereby increasing their risk of cardiovascular and metabolic disorders.^[36,37]

The findings of the present study should be interpreted considering the study's strengths and limitations. Firstly, this is the first study to report an association between DQI-I and MetS in obese adults. Secondly, another strength of this study, selecting obese subjects with a large and representative of the general population. In addition, dietary intake and household food security situation were assessed using locally validated questionnaires, the FFQ^[21] and HFSS,^[23] which were administered through face-to-face interviews by an experienced dietitian to minimize measurement errors. However, we acknowledge some limitations in the present study. First, the cross-sectional nature of this study limited the ability to suggest a causal association between DQI-I and food security with MetS and its features. Second, there might be possible small errors in the dietary assessment mainly due to remembering the data and misclassification error by using FFQ. Third, unbalanced gender which restrains us not to perform stratified analysis between male and female. Fourth, in the present study, although, we got association between DQI-I and MetS and some of its features, the validity of DQI-I has not been tested in this study, hence assessment of the validity and reliability of DQI-I in Iranian population is necessary.

In conclusion, a higher DQI-I score was associated with a reduced risk of MetS and some features such as hypertriglyceridemia and reduced HDL. Furthermore, household food insecurity was associated with an increased

risk of high blood pressure and hypertriglyceridemia in obese Iranian adults. These findings suggest that food security and better diet quality may be a protective factor in the development of MetS in obese subjects. Hence, efforts to improve diet quality and food insecurity should consider addressing the availability and accessibility to a high-quality healthy diet.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Acknowledgements

The authors are very grateful to all the participants of the study for their enthusiastic collaboration and to Tehran University of Medical Sciences International Campus (TUMS-IC) for the support, it provided to conduct this study.

Author's contribution

ARD, MQ, and AA designed the study. MF, MA and LA and AA contributed to the acquisition and analysis of data for the work. MB and AA worked on interpretation, wrote the first draft and prepared the final manuscript. All authors have read the manuscript and approved it.

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Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Received: 26 May 19 **Accepted:** 08 Jan 20

Published: 26 Oct 21

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