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Original Article

Association Between dietary patterns and the risk of metabolic syndrome among Iranian population: A cross-sectional study

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Background: The role of dietary patterns in metabolic syndrome has not been investigated sufficiently among Iranian population. The aim of this study is to investigate the association of major dietary patterns with the risk of metabolic syndrome and its components among healthy individuals of Iran.
Methods: This is a cross-sectional study that was performed on 5895 men and women who participated in MASHAD study project. Factor analysis was employed to determine major dietary patterns with regard to a validated 65-item food frequency questionnaire. Metabolic syndrome was diagnosed using international diabetes federation (IDF). Logistic regression analysis was used to evaluate the association between dietary patterns and metabolic syndrome risk to generate odds ratios (ORs) and 95% confidence intervals (CI).
Results: Three major dietary patterns (Balanced, Western and high carbohydrate) were identified. The Western pattern showed a positive association with metabolic syndrome (OR [95%CI] for highest vs. lowest tertile: 1.58 [1.21–2.06]; p value = 0.001). The high carbohydrate dietary pattern was associated with higher metabolic syndrome risk (OR [95%CI] for highest vs. lowest tertile: 1.17 [1.02–1.33]; P value = 0.022). The Balanced dietary pattern was unrelated to metabolic syndrome, but was related to some individual risk factors for metabolic syndrome.
Conclusions: These results suggest that the Western and high carbohydrate patterns are associated with an increased risk for metabolic syndrome among Iranian adults. The causality of these associations needs to be confirmed.

1. Introduction

Dietary habits are a component of the lifestyle-related risk factors [1] that affect the development of diseases such as metabolic syndrome [2–4]. Global prevalence of metabolic syndrome is about 10%–84% according to different populations and definitions [5], and is a combination of several risk factors including obesity, impaired glucose tolerance, hypertension and hyperlipidemia [6]. Hence, metabolic syndrome is associated with mortality and morbidity due to high risk of cardiovascular disease and diabetes

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mellitus [7].

The increasing prevalence of metabolic syndrome was observed in Asian populations which is estimated 10%–30% [8]. According to all three definitions (ATP III, IDF and JIS) the prevalence of metabolic syndrome is high and about 36.9% of Iranian population are diagnosed with metabolic syndrome which is higher than many other countries around the world [9]. Although various risk factors are attributed to this health problem [10,11], the association of dietary patterns with metabolic syndrome is well documented in different populations [4,12,13].

Dietary pattern changes are evident in developing countries as high dietary intake of fat and red meat and low dietary intake of carbohydrate and fiber have been observed in such populations [14]. Trends toward the increased intake of sodium and trans fats and low intakes of fruits, vegetables, fiber and whole grains have occurred in Iranian population [15] which might be associated with high prevalence of metabolic syndrome. Previous studies have indicated the association of main dietary patterns with metabolic syndrome in different populations [16–20]. The results of a systematic review and meta-analysis study indicated that the 'Healthy/Prudent' dietary pattern rich in fresh fruits, vegetables, whole grains and fish was associated with lower risk of metabolic syndrome and its components while the 'Unhealthy/Western' dietary pattern with high intake of red meat, processed meat, refined grains, sweets, French fries, desserts, eggs and high-fat dairy products was related with higher metabolic syndrome risk. A few studies have reported similar results in limited areas of Iran (Tehran and Isfahan) [21–23]. However, these findings are not generalizable to all Iranian population as they conducted on different strata of society including teachers with higher socioeconomic status [21] or unhealthy individuals [22]. Therefore, additional studies are required in this regard. The present study was conducted to evaluate the association of dietary pattern with the risk of metabolic syndrome and its components in Iranian population.

2. Material and methods

2.1. Study population

This research was designed as a cross-sectional study. All participants were recruited from the MASHAD study population [24]. Individuals with energy consumption <800 or >4200 kcal, or who left more than 10% of the FFQ items blank or lacking data regarding metabolic syndrome components (waist circumference, SBP, DBP, TG, glucose, and HDL-C) were excluded from the study. The remaining 5895 participants and their data were used for the final analysis. All participants were able to read and understand and were willing to sign the informed consent form. The study protocol was reviewed and approved by the ethics committee of Mashhad University of Medical Sciences (MUMS).

2.2. Data collection

All necessary data about participant's demographics (e.g., age, education and marital status), lifestyle (e.g., cigarette smoking and physical activity level), diet, medical history were collected through a questionnaire at baseline by health care professionals and a nurse interview [24]. A validated food frequency questionnaire (FFQ) was applied to determine dietary intake. The FFQ classifies 65 food items into 22 predefined food groups based on the food items similarity. To examine the average consumption of each food item 5 frequency categories (frequency of use per day, week, month, rarely and never) and serving size were considered. Height, weight, waist circumference, hip circumference, and mid-arm circumference were measured twice using a standard method [25]. The body mass index (BMI) was calculated by dividing weight to height squared (m2). Blood pressure was measured twice with a 30-min interval for all participant in seated and rested position using a standard mercury sphygmomanometer. The average of two measurements was used to report the final blood pressure. Blood samples were collected after 14 h overnight fasting and was used to determine the levels of triglycerides (TG), total cholesterol (TC), fasting blood glucose (FBG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) which were measured enzymatically using commercial kits.

2.3. Metabolic syndrome diagnosis

Based on the definition of the International Diabetes Federation (IDF) there are five components for metabolic syndrome (Metabolic syndrome) which are: fasting blood glucose ≥100 mg/dl, systolic or diastolic blood pressure ≥130 or ≥85 mmHg; HDL-C <50 mg/dl for women or <40 mg/dl for men; triglyceride ≥150 mg/dl; and waist circumference ≥80 cm for women or ≥94 cm for men) [26]. Those who have at least three or more components (n = 1890) were recognized as metabolic syndrome patients and healthy individuals were considered as control group (n = 4005).

2.4. Assessment of dietary pattern

Factor analysis (principal components) was used to derive dietary patterns based on the 22 food groups. To keep the factors uncorrelated and to achieve a greater interpretation, they were orthogonally rotated (varimax rotation). Components with an eigenvalue >1, the scree test and the interpretability of the factors were considered in determining the number of factors to retain. The factor scores were estimated for each dietary pattern after adding the consumption of the food groups weighted by their loading factor. Finally each individual received a score based on 3 identified dietary patterns.

2.5. Statistical analysis

Statistical analysis was performed using the SPSS version 18.0 (SPSS, Chicago, IL). The Kolmogorov- Smirnov test, t-tests, and Mann-Whitney U tests were used for comparing variables between metabolic syndrome + and Metabolic syndrome − groups. After assessing normality a two tailed P-value less than 0.05 was considered as significant. The significance of the differences between the averages was calculated by using one factor analysis of variance ANOVA. Logistic regression analysis was used to assess the relationship between metabolic syndrome (or its components) and tertiles of each dietary pattern while controlling for age, gender, BMI, physical activity level, education level, marital status, smoking and total energy intake taking the lowest tertile group as the reference group.

3. Results

Basic characteristics of the participants based on metabolic syndrome phenotype are presented (Table 1). The participants with metabolic syndrome were older and had higher weight, body mass index (BMI), waist circumference (WC), hip circumference (HC), waist to hip ratio (WHR), mid-upper arm circumference (MAC), systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood glucose (FBG), total cholesterol (TC) and triglyceride (TG) than the control subjects ($P < 0.001$). Moreover, metabolic syndrome patients had lower education level, physical activity level (PAL) and high density lipoprotein cholesterol (HDL-C) concentration compared to control subjects ($P < 0.001$).

Table 1
Comparison of the demographic, anthropometric, and biochemical parameters for the participants with and without metabolic syndrome.

	MetS + (N = 1890)	MetS – (N = 4005)	P value
Gender Male, % (N)	31 (586)	45.5 (1824)	<0.001
Age, year	50.11 ± 7.76	47.56 ± 8.21	<0.001
Marriage status, % (N)			
Single/divorced/widow	7 (132)	6 (240)	0.144
Married	93 (1758)	94 (3765)	
Education level, year	7.47 ± 4.89	8.44 ± 4.84	<0.001
Smoking status % (N)			
Ex- smoker	10 (189)	10 (402)	0.782
Current smoker	20.60 (390)	19.9 (795)	
Weight, kg	76.17 ± 12.37	70.06 ± 12.50	<0.001
Height, cm	159.53 ± 0.09	161.02 ± 0.09	<0.001
BMI (kg/m^2)	29.92 ± 4.23	27.07 ± 4.62	<0.001
Waist circumference (cm)	100.38 ± 12.17	92.29 ± 12.17	<0.001
Hip circumference (cm)	106.49 ± 8.92	102.37 ± 9.38	<0.001
WHR	0.94 ± 0.07	0.90 ± 0.08	<0.001
Mid-upper arm circumference (cm)	31.36 ± 3.27	30.11 ± 4.29	<0.001
PAL	1.55 ± 0.26	1.62 ± 0.30	<0.001
SBP (mm Hg)	129.79 ± 19.91	118.66 ± 17.04	<0.001
DBP (mm Hg)	83.88 ± 11.67	77.43 ± 10.06	<0.001
FBG (mg/dl)	106.51 ± 48.34	86.61 ± 30.17	<0.001
Total cholesterol (mg/dl)	197.28 ± 38.87	189.70 ± 38.19	<0.001
Triglyceride (mg/dl)	200.93 ± 108.34	115.11 ± 63.08	<0.001
LDL-C (mg/dl)	115.56 ± 37.13	116.06 ± 34.36	0.608
HDL-C (mg/dl)	37.57 ± 6.33	45.64 ± 10.28	<0.001

Data presented as mean ± standard deviation or percentage (number). Independent sample *t*-test were used in normal distributed data. Abbreviations: BMI: body mass index; WHR: waist/hip ratio; PAL: physical activity level; SBP: systolic blood pressure; DBP: Diastolic blood pressure; FBG: fasting blood glucose; LDL-C: Low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol, MetS: Metabolic Syndrome.

Table 2
Factor-loading matrix for the three major dietary patterns identified by factor analysis in the MASHAD cohort study participants.

Food items	balanced dietary pattern	Western dietary pattern	High carbohydrate dietary pattern
Other vegetables	0.66	–	–
Green leafy vegetables	0.64	–	–
Fruits	0.56	–	–
Dairy products	0.51	–	–
Red meats	0.39	0.22	–
Poultry	0.29	–	–
Legumes	0.25	–	–
Liquid foods	–	–	–
Sugar	–	0.65	0.25
Tea	–	0.55	–
Eggs	–	0.48	–
Potato	–	0.42	–
Snacks	–	0.38	0.29
Organs meat	–	0.33	–
Nuts	–	0.29	–
Butter	–	0.27	–
Pickled foods	–	0.24	–
Whole grains	–	–	–0.55
Refined grains	–	–	0.54
Carbonated beverages	–	0.31	0.37
Fast foods	–	–	0.36
Coffee	–	–	0.28
Sea foods	0.21	–	0.26
Total variance	8.44	8.39	6.16

Values < 0.20 were excluded for simplicity.

Factor-loading matrixes for the 3 major factors are listed in Table 2. Three major dietary patterns were identified that explained 23% of the total variance. The "Balanced" dietary pattern was characterized by high positive loadings for the consumption of other vegetables, green leafy vegetables, fruits, dairy products, red meats, poultry and legumes. The second pattern which we labeled "Western" dietary pattern showed positive loadings for the consumption of sugar, tea, eggs, potato, snacks, organs meat, nuts, butter, pickled foods, carbonated beverages and red meats. The third dietary pattern which was labeled "High carbohydrate" dietary pattern was characterized by high positive loadings for the consumption of refined grains, carbonated beverages, fast foods, snacks, sugar, coffee, sea foods and negative loadings for the consumption of whole grains.

The characteristics of participants across the tertiles of each dietary pattern are indicated in Table 3 – 5. Higher adherence to the Balanced pattern was associated with decreasing age, percentage of married subjects, BMI, DBP, TC, TG, FBG, education level and PAL as well as with increasing weight, height, WC and percentage of ex-smoker and current smoker subjects (P-value<0.05) (Table 3). On the other hand, from T1 to T3 of Western dietary pattern we observed increasing age, PAL, BMI, SBP, DBP, TC, TG, FBG and LDL-C,

Table 3
Characteristics of study participants according to the tertiles of Balanced dietary pattern.

Tertile of dietary pattern score				
Balanced pattern	T1	T2	T3	P value
Age, years	49.22 ± 8.06	47.68 ± 8.21	48.65 ± 8.07	<0.001
Sex (% male)	40.60	38.70	43	0.004
Education, year	9.68 ± 4.76	6.89 ± 4.68	8.90 ± 4.80	<0.001
Smoking status (%)				
Ex-smoker	9.1	10	10.2	<0.001
Current smoker	16.2	23.5	18.2	
Marital status (% married)	94.30	92.40	94.80	0.002
PAL	1.61 ± 0.29	1.62 ± 0.29	1.58 ± 0.28	0.001
Weight, kg	72.72 ± 12.27	70.63 ± 12.87	73.09 ± 12.67	<0.001
Height (cm)	160.58 ± 0.09	159.90 ± 0.09	161.16 ± 0.09	<0.001
BMI	28.26 ± 4.59	27.67 ± 4.77	28.18 ± 4.62	<0.001
Hip circumference	103.05 ± 9.32	103.80 ± 9.53	103.76 ± 9.34	0.111
Waist circumference (cm)	93.64 ± 12.17	94.89 ± 12.28	95.12 ± 11.92	0.008
WHR	0.91 ± 0.08	0.91 ± 0.08	0.92 ± 0.08	0.054
SBP (mmHg)	122.53 ± 18.99	121.76 ± 17.91	122.21 ± 19.30	0.516
DBP (mmHg)	79.82 ± 11.10	79.01 ± 10.88	79.71 ± 11.07	0.045
Total cholesterol (mg/dl)	195.23 ± 37.84	191.05 ± 37.07	191.87 ± 40.04	0.024
Triglyceride (mg/dl)	150.80 ± 99.26	137.35 ± 86.03	144.17 ± 88.55	<0.001
FBG (mg/dl)	96.40 ± 40.72	92.10 ± 37.42	91.79 ± 36.09	0.006
LDL-C (mg/dl)	115.31 ± 36.67	116.66 ± 34.17	114.99 ± 35.75	0.225
HDL-C (mg/dl)	43.25 ± 10.28	43.31 ± 9.76	42.79 ± 10.03	0.163

Abbreviations: BMI: body mass index; WHR: waist/hip ratio; PAL: physical activity level; SBP: systolic blood pressure; DBP: Diastolic blood pressure; FBG: fasting blood glucose; LDL-C: Low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol.

Table 4
Characteristics of study participants according to the tertiles of Western dietary pattern.

Tertile of dietary pattern score				
	T1	T2	T3	P value
Age	46.69 ± 7.69	47.10 ± 7.87	49.78 ± 8.24	<0.001
Sex (% male)	63.70	45.40	32.10	<0.001
Education, year	8.50 ± 4.55	8.27 ± 4.82	7.97 ± 4.98	0.020
Smoking status (%)				
Ex-smoker	15.30	10.20	8.70	<0.001
Current smoker	35	23.10	14.60	
Marital status (% married)	95.70	95.20	91.90	<0.001
PAL	1.56 ± 0.32	1.58 ± 0.29	1.62 ± 0.28	<0.001
Weight (kg)	72.95 ± 12.66	72.30 ± 12.72	71.50 ± 12.78	0.014
Height (cm)	164.44 ± 0.09	161.56 ± 0.09	158.83 ± 0.09	<0.001
BMI	27.08 ± 4.75	27.75 ± 4.66	28.36 ± 4.66	<0.001
Hip circumference	102.85 ± 8.99	103.68 ± 9.27	103.82 ± 9.64	0.095
Waist circumference (cm)	93.98 ± 11.61	94.84 ± 12.07	94.93 ± 12.26	0.251
WHR	0.91 ± 0.08	0.91 ± 0.08	0.91 ± 0.08	0.969
SBP (mmHg)	120.20 ± 16.67	120.61 ± 17.40	123.79 ± 20	<0.001
DBP(mmHg)	79.15 ± 10.35	78.92 ± 10.98	79.96 ± 11.11	0.002
Total cholesterol (mg/dl)	188.63 ± 39.91	190.52 ± 37.47	194.05 ± 39.07	<0.001
Triglyceride (mg/dl)	140.87 ± 93.76	139.24 ± 85.99	145.27 ± 91.25	0.046
FBG (mg/dl)	87.06 ± 31.79	89.90 ± 34.05	96.20 ± 40.89	<0.001
LDL-C (mg/dl)	112.14 ± 35.89	115.93 ± 34.88	116.28 ± 35.38	0.044
HDL-C (mg/dl)	42.73 ± 9.98	42.80 ± 9.98	43.41 ± 9.92	0.055

Abbreviations: BMI: body mass index; WHR: waist/hip ratio; PAL: physical activity level; SBP: systolic blood pressure; DBP: Diastolic blood pressure; FBG: fasting blood glucose; LDL-C: Low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol.

while percentage of male, married, ex-smoker and current smoker subjects, weight and height decreased (P-value<0.05) (Table 4). We also found higher age, WHR, SBP and percentage of ex-smoker and current smoker subjects and lower weight, height and education level in the upper tertile of high carbohydrate pattern compared to the lower tertile (P-value<0.05) (Table 5).

The association of three major dietary patterns and metabolic syndrome and its components are indicated by logistic regression analysis in Table 6. After adjusting for age, gender, BMI, PAL, smoking, education level, marital status and total energy intake, higher tertile of the Balanced pattern was not significantly associated with metabolic syndrome (OR = 0.90, 95%CI = 0.73–1.11, P value = 0.343), however higher odds of abdominal obesity (OR = 1.46, 95% CI = 1.14–1.86, P value = 0.002) and lower odds of high FBG (OR = 0.75, 95%CI = 0.62–0.92, P value = 0.006) were observed in the upper tertile of the Balanced pattern. In addition, higher score of Western dietary pattern was associated with increased odds of metabolic syndrome (OR = 1.58, 95% CI = 1.21–2.06, P value = 0.001), high FBG (OR = 1.54, 95% CI = 1.13–2.12, P value = 0.007) and low HDL-C (OR = 1.36, 95% CI = 1.07–1.72, P value = 0.01). We also found that subjects in the upper tertile of high carbohydrate dietary pattern had higher odds of metabolic syndrome (OR = 1.17, 95%CI = 1.02–1.33, P value = 0.023) and low HDL-C (OR = 1.16, 95%CI = 1.02–1.32, P value = 0.022).

Table 5
Characteristics of study participants according to the tertiles of high carbohydrate dietary pattern.

Tertile of dietary pattern score	T1	T2	T3	P value
Age	48.20 ± 8.11	46.38 ± 7.97	49.43 ± 8.12	<0.001
Sex (% male)	39.70	43.70	41.40	0.099
Education, year	8.56 ± 4.83	9.01 ± 4.94	7.06 ± 4.73	<0.001
Smoking status (%)				
Ex-smoker	8.40	8.80	13.20	<0.001
Current smoker	18.40	22.80	21.90	
Marital status (% married)	93.60	94.30	93.50	0.708
PAL	1.60 ± 0.29	1.58 ± 0.28	1.61 ± 0.29	0.058
Weight (kg)	72.06 ± 12.61	73.08 ± 13.25	71.35 ± 12.77	0.004
Height (cm)	160.55 ± 0.09	161.57 ± 0.09	160.02 ± 0.09	<0.001
BMI	27.99 ± 4.59	28.03 ± 4.79	27.92 ± 4.81	0.806
Hip circumference	103.68 ± 9.21	104.20 ± 9.43	103.42 ± 9.76	0.132
Waist circumference (cm)	94.51 ± 11.93	94.89 ± 12.25	95.27 ± 12.36	0.102
WHR	0.91 ± 0.08	0.91 ± 0.09	0.92 ± 0.08	<0.001
SBP (mmHg)	121.51 ± 17.70	120.83 ± 18.19	123.59 ± 20.34	<0.001
DBP (mmHg)	79.31 ± 10.90	79.02 ± 11.18	79.81 ± 11.07	0.152
Total cholesterol (mg/dl)	192.63 ± 38.64	190.31 ± 36.52	191.74 ± 39.13	0.277
Triglyceride (mg/dl)	139.90 ± 83.07	142.23 ± 91.97	146.14 ± 97.56	0.058
FBG (mg/dl)	92.62 ± 36.89	91.11 ± 35.49	93.25 ± 39.05	0.381
LDL-C (mg/dl)	116.16 ± 35.46	115.04 ± 35	115.39 ± 34.92	0.617
HDL-C (mg/dl)	43.25 ± 9.84	43.20 ± 10.06	42.73 ± 10.09	0.189

Abbreviations: BMI: body mass index; WHR: waist/hip ratio; PAL: physical activity level; SBP: systolic blood pressure; DBP: Diastolic blood pressure; FBG: fasting blood glucose; LDL-C: Low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol.

Table 6
Multivariable adjusted odds ratio (OR) and their 95% confidence interval (CI) for the association between tertiles (T) of dietary pattern scores and the metabolic syndrome and its components in MASHAD study participants.

Tertile of dietary pattern score	T1	T2	T3	P value
Balanced pattern				
Metabolic syndrome	1	0.81 (0.65–1)	0.90 (0.73–1.11)	0.343
Abdominal obesity	1	1.82 (1.39–2.39)	1.46 (1.14–1.86)	**0.002**
Elevated blood pressure	1	0.87 (0.69–1.08)	0.94 (0.77–1.16)	0.584
High triglyceride	1	0.74 (0.61–0.89)	0.86 (0.73–1.03)	0.095
High fasting blood glucose	1	0.60 (0.48–0.74)	0.75 (0.62–0.92)	**0.006**
Low HDL cholesterol	1	1.02 (0.85–1.23)	1.09 (0.92–1.29)	0.328
Western pattern				
Metabolic syndrome	1	1.22 (0.96–1.56)	1.58 (1.21–2.06)	**0.001**
Abdominal obesity	1	1.04 (0.78–1.40)	0.75 (0.54–1.05)	0.140
Elevated blood pressure	1	0.91 (0.70–1.19)	1.08 (0.81–1.45)	0.593
High triglyceride	1	0.94 (0.75–1.16)	1.13 (0.89–1.44)	0.319
High fasting blood glucose	1	1.14 (0.85–1.53)	1.54 (1.13–2.12)	**0.007**
Low HDL cholesterol	1	1.32 (1.07–1.63)	1.36 (1.07–1.72)	**0.01**
High carbohydrate pattern				
Metabolic syndrome	1	1.07 (0.89–1.28)	1.17 (1.02–1.33)	**0.023**
Abdominal obesity	1	1.08 (0.85–1.37)	1.08 (0.90–1.30)	0.394
Elevated blood pressure	1	0.97 (0.79–1.20)	0.96 (0.82–1.11)	0.586
High triglyceride	1	1 (0.84–1.19)	1.06 (0.94–1.21)	0.335
High fasting blood glucose	1	1.19 (0.96–1.46)	1.03 (0.88–1.19)	0.741
Low HDL cholesterol	1	0.96 (0.81–1.14)	1.16 (1.02–1.32)	**0.022**

Metabolic syndrome was defined as having at least three out of five criteria: 1) waist circumference ≥ 94 cm in males and ≥80 cm in females; 2) elevated blood pressure (≥130/85 mmHg); 3) high triglyceride (≥150 mg/dl); 4) high fasting blood glucose (≥100 mg/dl); 5) HDL cholesterol ≤ 40 mg/dl in males and ≤50 mg/dl in females. The OR was adjusted for age, sex, body mass index, physical activity level, smoking status, education level, marital status and total energy intake.

4. Discussion

We identified three major dietary patterns among the study population. The "balanced" dietary pattern as a healthy dietary pattern was not associated with the risk of metabolic syndrome whereas a positive association were found between adherence to the "western" and "high carbohydrate" dietary patterns and the risk of metabolic syndrome. In addition, these three major dietary pattern affected the metabolic syndrome risk factors differentially.

Several epidemiological studies have found an inverse association between metabolic syndrome and healthy or prudent dietary patterns rich in fruits, vegetables and whole grains [21,27–29]. However, in the present study the balanced pattern as a healthy pattern (high in other vegetables, green leafy vegetables, fruits, dairy products, red meats, poultry, legumes and liquid foods) was not associated with metabolic syndrome risk. In a cross-sectional study of 460 Japanese working population the healthy Japanese dietary pattern characterized by high intake of vegetables and fruits, soy products, mushrooms, and green tea was not associated with the prevalence of metabolic syndrome or its components [30]. In a cohort study among 9514 middle-aged US adults no association was found between adherence to the prudent dietary pattern (by high intake of cruciferous and carotinoid vegetables, fruit, fish, and poultry) and metabolic syndrome risk [31]. Surprisingly we found that the balanced pattern increased the abdominal obesity risk as one of the metabolic syndrome components. Healthy dietary pattern that is reach in fruits and vegetables is known to decrease the risk of abdominal obesity [32–34]. This inconsistency could be explained based on differences in socio-demographic characteristics, behavioral and lifestyle factors. In addition, high intake of meat sources (including red meat, poultry and sea foods) might be attributed to increased odds of abdominal obesity in participants with high score of balanced pattern because of higher energy and fat contents of these food groups [35]. Consistently with results of recent studies, the balanced pattern (high in vegetables, fruits, dairy products, red meat, poultry, legumes, liquid foods) in the present study appears to be associated with lower risk of high FBG. High intakes of fruits, vegetables and complex carbohydrates in healthy patterns are main dietary fiber sources which are responsible for reducing diabetes risk [36].

The results of our study are in accordance with majority of studies which indicated western/unhealthy patterns have been associated with a higher risk of Metabolic syndrome [4,21,29,37–39]. However, the results of several studies have not unequivocally confirmed such relationships and no association was found between western/unhealthy dietary pattern with metabolic syndrome [4,40,41]. Western/unhealthy dietary patterns with high intakes of starch, sugar, saturated fatty acids and trans fats and low intake of fruits, vegetables and whole grains increase the risk of metabolic syndrome and its components through affecting immune system function [42]. Different findings related to above mentioned associations might be due to the various dietary patterns based on gender, ethnicity, cultures and geographical regions [43].

Compared to low adherence, high adherence to western pattern was associated with increased odds of high fasting blood glucose after adjusting for confounding factors. Unhealthy dietary pattern which is characterized by high dietary carbohydrate sources may increase the risk of diabetes because of high glycemic index and glycemic load of this macronutrient [44]. Besides, Western dietary pattern with high intakes of processed meats may leads to high risk of type 2 diabetes [45]. Our findings also demonstrated low HDL-C level of participants in the upper tertile of the Western pattern. A population-based prospective cohort study in the south of Sweden reported an inverse association between the 'Western' dietary pattern (which characterized by high intakes of sugar-sweetened beverages, reduced fat milk, artificially sweetened beverages, red and processed meat and sweets) and HDL-C level [46].

The "high carbohydrate" dietary pattern (high intake of sugars, refined grains, fast foods, coffee, sea foods and snacks and low intake of whole grains) was associated with higher metabolic syndrome risk. High consumption of food groups with high glycemic index is positively associated with metabolic syndrome prevalence through affecting insulin resistance [47]. We also found that high carbohydrate pattern was associated with decreased HDL-C levels. In agreement with previous studies low fat, high carbohydrate diets tends to decrease the HDL-C levels [48].

The strength of the current study includes a relatively large sample size which provides useful information to investigate the effect of dietary habits on metabolic syndrome in Iranian adults as a population with a high prevalence of metabolic syndrome. The study participants classified according to the IDF definition [26], which provides one of the most widely used classifications of metabolic syndrome. However there are several limitations. First, this is a cross-sectional study which indicates uncertain causality between dietary patterns and metabolic syndrome risk. Second, the three dietary patterns identified in our results may not generalize to all Iranian adults since they explained 23% of total variance. Third, an objective decision was made at different levels of extracting dietary pattern by factor analysis which is effective on the interpretation of results.

5. Conclusion

The results of this study suggest that dietary pattern plays an important role in the management of metabolic syndrome among Iranian adults. Although intake of the balanced dietary pattern was not associated with metabolic syndrome risk, adherence to Western dietary pattern or high-carbohydrate dietary pattern were positively associated with risk of metabolic syndrome. More investigations are needed to confirm these findings.

Ethics approval and consent to participate

The study protocol, informed consent form and other study-related documents were reviewed and approved by the Human Research Ethics Committee of Mashhad University of Medical Sciences (MUMS). All patients were able to read and understand and were willing to sign the informed consent form.

Consent for publication

Not applicable.

Conflicts of interest

The authors declare that they have no competing interest.

Conflicts of interest

The authors have no conflict of interest to disclose.

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Authors' contributions

Zahra Asadi wrote the paper; Majid Ghayour Mobarhan, Alireza Heidari-Bakavoli, Mohsen Mouhebati designed the study; Majid Ghayour-Mobarhan supervised the data collection; Mojtaba Shafiee, Fatemeh Sadabadi collected the data; Maryam Tayefi, Habibollah Esmaeili analyzed the data, Maryam Saberi-Karimian, Hamideh Ghazizadeh, Sousan Daroudi provided statistical expertise, Gordon Ferns extensively reviewed and edited the manuscript; and all authors were involved in interpretation of results and revision of the manuscript and approved the final version of the manuscript.

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Abbreviations

BMI Body mass index

BP	Blood pressure
CI	Confidence interval
DBP	Diastolic blood pressure
FBG	Fasting blood glucose
FFQ	Food frequency questionnaire
HDL-C	High-density lipoprotein cholesterol
IDF	International diabetes federation
LDL-C	Low-density lipoprotein cholesterol
Mets	Metabolic syndrome
OR	Odds ratio
PAL	Physical activity level
SBP	Systolic blood pressure
TG	Triglyceride
WHR	Waist to hip ratio

Appendix A: Food list of 23 food groups in the FFQ of the present study.

Food group	Food items
Other vegetables	Tomato, cucumber, onion, garlic
Green leafy vegetables	Green vegetables, lettuce, spinach
Fruits	Trees fruit, seasonal fruit, fresh fruit juice, dried fruit
Dairy products	Whole milk, low fat milk, yogurt, cheese, cream
Red meats	Lamb meet, beef meat, minced meat
Poultry	Poultry and chicken barbecue
Legumes	Legumes
Liquid foods	Soup, Pottage
Sugar	Sugar, diabetic sugar, honey
Tea	Tea
Eggs	Fried egg, boiled egg
Potato	Boiled potato, fried potato, potato in other foods, fried potato with egg
Snacks	Biscuit, cake, ice cream, chips, chocolate
Organs meat	Lamb organs
Nuts	Nuts
Butter	butter
Pickled foods	Sour and salty pickles
Whole grains	Whole bread
Refined grains	White bread, rice, spaghetti
Carbonated beverages	Coke, diet coke, free alcohol beer
Fast foods	Pizza, red meat products
Coffee	Coffee
Sea foods	Fresh fish, canned fish, shrimp and other sea foods

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