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Original article

The association between a dietary habits score and the risk of metabolic syndrome: A cohort study

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SUMMARY

Background: Dietary habits are proposed to affect the risk of metabolic syndrome (MetS). The present study aimed to investigate the association between a dietary habits score (DHS) and the risk of MetS and its components among Iranian adults.

Materials and methods: In this cohort study 1092 participants without MetS were followed up to 10 years. The baseline data on general characteristics as well as dietary habits were assessed through interview. The modified National Cholesterol Education Program, adult treatment panel III guideline was used to define MetS. The hazard ratio for the association between each dietary habit and MetS was used to calculate the DHS for each participant and the participants were categorized into quartiles based on their final calculated score.

Results: In total, 809 (74.1%) with mean age of 43 ± 14.4 years were followed. The risk of abdominal obesity (HR = 3.43, 95%CI: 1.97–5.94), low HDL cholesterol (HR = 3.01, 95%CI: 1.62–5.62), hyperglycemia (HR = 3.06, 95%CI: 1.58–5.94), and hypertension (HR = 3.44, 95%CI: 1.85–6.37) and MetS (HR = 2.94, 95% CI: 1.6–5.39) were significantly higher in those with the highest DHS compared with subjects categorized in the lowest quintile of DHS after adjustment for all possible confounders. There was a linear trend between the dietary habit score and the risk of developing MetS and its components ($P < 0.05$).

Conclusion: The DHS was significantly associated with an increased risk of MetS and some of its components. Future studies are needed to confirm the approach used to calculate the DHS and its association with the risk of MetS and its components in other populations.

1. Background

Metabolic syndrome (MetS) is a cluster of known risk factors for non-insulin dependent diabetes mellitus (NIDDM) and cardiovascular diseases (CVDs) [1,2]. Therefore, the morbidity and mortality rate might be increased in people affected by these risk factors [3]. It is proposed that more than 30% of Iranian adults are affected by MetS [4]; this prevalence is more than the majority of developed countries [5]. The prevalence of MetS is even higher in Yazd city as a recently published study revealed that more than 39% of adult female teachers are affected by MetS [6]. Furthermore, it is revealed that about 56.1% of adults without MetS living in central Iran, were newly affected by the syndrome in a 10-year follow-up study [7].

Several risk factors including gene polymorphisms [8], general and abdominal obesity [9], gender, age, smoking, high physical activity, socioeconomic status [10,11] and dietary patterns including westernized dietary patterns [12] are mentioned for MetS. Dietary habits are also supposed to affect the risk of Mets and its components such as obesity [13] and high fasting blood glucose [14]. The habitual decisions to choose food are considered as the

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dietary habits [15,16]. The consumption of high-fat meat versus low-fat meat, low-fat dairy product versus high-fat dairy product, removing fat and skin from poultry, type of cooking such as frying and boiling food, and consumption of salad and mayonnaise as salad dressing are some examples of the dietary habits [15].

A limited number of studies have considered the dietary habits in association with MetS. For instance, oily foods [17], eating fast foods [18], consumption of high-fat foods and a diet high in salt [19] are associated with the increased risk of MetS while vegetables, dairy products, [20] consumption of low fat milk and legumes [19] might decrease the risk of Mets.

As the human beings might simultaneously imitate several dietary habits, examining the association between each dietary habit in association with disease risk might not be practical. For instance a person might eat salad and also consume fried foods and usually add salt to his/her food. Therefore, designing a dietary food habits score which takes a combination of food habits into account might better show the association between association between the dietary habits and the risk of MetS. Nowadays, scales are used to quantify a set of variables such as dietary habits, and these scales are a set of questions to define an attribute. Total score that originated from summing all weighted questions after adjusting potential confounders shows individuals' attributes [21,22]. Therefore, providing a scoring system is important to estimate more accurate risk of clinical outcomes related to some behaviors [22]. To the best of our knowledge, no scoring system is now developed for dietary habits. Therefore, the main purpose of this study was to develop a dietary habits score (DHS) and to examine its association with the risk of MetS and its components in the context of a 10-year follow-up study in Iranian adults.

2. Materials and methods

2.1. Study population

The present follow-up study was initiated in 2005–2006 with 2000 participants that were recruited using cluster random sampling method from Yazd city, Central Iran [Yazd Healthy Heart Project (YHHP)]. Criteria for calculating the sample size (n = 2000) was based on the prevalence of diabetes (14%) in Yazd in 2005, and power of 80% and alpha of 0.05. One hundred clusters were randomly selected from the Yazd city and subsequently, 20 families were included from each clusterAfter that, one adult subject was selected from each family [7]. In the first phase, 21 participants were excluded because of the missing data. Therefore, 1979 were invited again to Yazd Cardiovascular Research Center (YCRC) in the second phase of the study to determine the incidence of MetS and cardiovascular diseases in the second phase which was conducted in 2015–2016, after about 10 years. In both waves, data on demographics, anthropometry (weight, height, and waist circumference), socioeconomic status, education, physical activity, smoking status and dietary habits as well as biochemical assessments including fasting blood glucose, triglyceride and HDL cholesterol levels were recruited.

Participants with MetS at the initiation phase (phase 1) and those with missing data on anthropometry and biochemical assessments were excluded from the current analysis. Furthermore a number of participants were lost in the follow-up phase and could not be accessed; therefore, we also excluded them from the current study.

2.2. Ethical approval

The present study was ethically approved by the Shahid Sadoughi University of Medical Sciences' ethics committee (ethics code: IR.SSU.MEDICINE.REC.1395.287). Informed consents were obtained from study participants at the initial and the follow-up phase. The present research is reported based on the strengthening the reporting of observational studies in epidemiology (STROBE) statement [23].

2.3. Developing the dietary habits score (DHS)

We used a dietary habits questionnaire in the first phase of the study in which the participants were asked to report their usual dietary habits including: having a dietary plan to control their body weight (yes/no), eating salad (yes/no), adding salt to food at the table (yes/no), cutting the skin off when eating poultry (yes/no), paying attention to food labels before buying and consuming foods (yes/no), usually dine out (yes/no), usually eat fast foods (yes/no), usually use frying (yes/no), roasting (yes/no) or boiling (yes/no) for cooking, removing the visible fat from meat when cooking (yes/no), and using special measuring cup for adding salt and oil to food when cooking (yes/no). In a previous study, we examined the association between each dietary habit item and the risk of developing MetS adjusted for the maximum number of variables in male and female participants as well as the total population [24]. To calculate the overall dietary habit score for each participant, the hazard ratios assigned to dietary habit items were summed up. The hazard ratios used for individual dietary habits to calculate the

Table 1
The scores used for calculating the dietary habits score (DHS) in men, women and the total population.

Dietary habits	Score		
	Men	Women	Total
Having weight Control plan			
Yes	1	1	1
No	1.72	1.22	1.57
Consuming low-fat meat			
Yes	1	1	1
No	1.13	0.62	0.98
Eating salad			
Yes	1	1	1
No	2.41	0.89	1.91
Adding salt to food			
No	1	1	1
Yes	1.4	2.16	1.57
Cut poultry skin off			
Yes	1	1	1
No	0.63	0.79	0.66
Attention to food labels when buying or cooking			
Yes	1	1	1
No	0.95	0.86	0.93
Dining out			
No	1	1	1
Yes	1.21	0.86	1.09
Eating fast food			
No	1	1	1
Yes	1.62	0.66	1.3
Using measuring cup for oil			
Yes	1	1	1
No	1.41	0.6	0.88
Using measuring cup for salt			
Yes	1	1	1
No	1.61	0.77	1.3
Boiling as the main cooking method			
Yes	1	1	1
No	0.74	1.26	0.84
Frying as the main cooking method			
No	1	1	1
Yes	0.74	1.24	0.86
Roasting as the main cooking method			
No	1	1	1
Yes	0.74	1.24	0.74

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overall score are summarized in Table 1. The dietary habit would get worse as the dietary habit score increases. The study participants were then categorized into quartiles based on their final calculated DHS. Participants in the highest quartile had the highest unhealthy dietary habits score and participants in the lowest quartile had the lowest unhealthy dietary habits.

2.4. Definition of the metabolic syndrome

In the current study, a modified version of National Cholesterol Education Program, Adult Treatment Panel III criteria (NCEP-ATP III) were used to define the MetS [25–27]. Existence of at least three of five following components of MetS was defined as MetS: abdominal obesity, hyperglycemia, dyslipidemia (for triglyceride and HDL cholesterol) and hypertension. In this study, central obesity was considered as waist circumference ≥91.5 for men and ≥85.5 cm for women (the criteria were adopted for Iranian population) [28]. High fasting blood glucose (FBG) was defined as FBG≥100 mg/dL or consuming pharmacological treatment to control blood sugar. Hypertriglyceridemia was defined as triglyceride level ≥150 mg/dL or consuming triglyceride lowering agents. Criteria for low HDL-cholesterol was HDL<40 mg/dL in men and <50 mg/dL in women or pharmacological treatment use. Subjects with systolic/diastolic blood pressure ≥130/85 mmHg or used pharmacological treatment for high blood pressure were categorized as hypertensive.

2.5. Biochemical analysis

To assess biochemical test in both phases, 5 cc of venous blood sample was taken after 9–12 h of fasting. After centrifugation in order to separate serum, fasting blood glucose and triglyceride were assessed using Pars Azmoon Kits (Pars Azmoon Inc., Tehran, Iran). Bionic kits (Bionic Company, Tehran, Iran) were used to analyze HDL cholesterol. All analyses were conducted using a biochemical auto-analyzer (BT 3000, Italy).

2.6. Anthropometric and blood pressure measurements

A stadiometer fixed on the wall without any dents or bumps was used to measure height in both phases. The height was measured when participants were standing barefoot and their heel, hip, shoulder and head were touching the wall and their head was fixed horizontally to the nearest 0.5 cm. With minimal clothing, participants were weighted using a digital scale (Seca, Germany) at the first phase and another digital scale (Model BF511, Omron Co. Karada body scan, Osaka, Japan) at the second phase to the nearest 0.1 kg. The superior border of the iliac crest was considered to measure waist circumference to the nearest 0.1 cm by using a non-stretchable tape. Blood pressure was measured in the right arm which was supported on the chair by an automatic digital blood pressure monitor (Omron, M6 comfort, Osaka, Japan). The blood pressure measurements were performed two times separated with five minutes by a trained nurse.

2.7. Other covariates

Other covariates including economic status, physical activity, education and smoking status were assessed using on a questionnaire that was filled by a trained interviewer, at the first phase. The economic status was assessed using the participants' usual household income, having a private car and the home area (m^2). We assigned a score to each question and participants were categorized as low, moderate and high economic status based on tertiles of the overall calculated summed score. Participants were categorized to primary, high school and academic based on their education. The International Physical Activity Questionnaires (IPAQ) [29] was used to assess the physical activity and subjects were divided to low, moderate and vigorous activity if their activity was <600, 600–1200 and > 1200 kilocalories/week, respectively. Also, participants were divided into two groups based on their current smoking status (smokers and non-smokers).

2.8. Statistical analysis

Data are reported as mean ± standard deviation (SD), otherwise specified. Categorical and quantitative variables were compared based on the quartiles of the DHS using chi-square and analysis of variance (ANOVA) tests, respectively. The Analysis of Covariance (ANCOVA) was applied to compare the mean change (the difference between baseline and after 10-year follow-up values) in the MetS components according the quartiles of the DHS in men, women and the total population in crude and multivariable adjusted models. In model I, the association was adjusted for age and sex (when associations were explored in the total population) and in model II, variables including smoking status, economic status, physical activity and education were further adjusted. Cox proportional hazard regression model was used to find the association between dietary habits and the risk of MetS and its components in crude and multivariable adjusted models in males and females as well as the total population. The covariates were the same as variables adjusted in the ANCOVA. Statistical package for social sciences (SPSS) software version 19 (IBM Corporation, New York, USA) was used to conduct all statistical analyses. The statistically significant associations were defined as P values ≤ 0.05.

3. Results

From 1979 participants who had data at the first phase of the study, 1092 (55.2%) subjects did not have MetS and were included in the current study. After about 10 years of follow-up, 809 (74.1%) out of 1092 participants with mean age of 43 ± 14.4 years were followed-up and 283 (25.9%) subjects were lost to follow-up and the cumulative incidence rate of MetS was 56.1% [7]. The overall dietary habit score was ranged between 10.57 and 14.98 for men, 8.65 to 11.88 for women and 12.36 to 15.52 for the total population.

The baseline characteristics of the study participants based on quartiles of the DHS are provided in Table 2. There was a statistically significant association between DHS and education. The number of highly educated participants decreased as the adherence to the dietary habits score was higher (P < 0.05). There were no statistically significant difference in quantitative variables (such as age, weight, BMI, systolic/diastolic blood pressure, serum fasting blood glucose, triglycerides, HDL cholesterol, and waist circumference) and other categorical variables (like sex, smoking status, socioeconomic status, and physical activity level) based on the quartiles of DHS, at baseline (Table 2).

Table 3 represents the comparison of the mean MetS components at baseline, after follow-up and their change during the follow-up period according to the quartiles of the DHS in men and women, as well as the total population in crude, and multivariable adjusted models. The analyses revealed that women in the highest quartile of the DHS had a significantly lower systolic blood pressure (SBP) at baseline (P = 0.05) and at follow-up period (P = 0.018), however the change in systolic blood pressure was significantly different according to the dietary habits score neither in crude nor multivariable adjusted models. Women with highest DHS had a significantly lower serum triglyceride (TG) levels (P = 0.027), but not in the follow-up visit (P = 0.844). When the change in serum TG levels was investigated, we saw a significant increase in females with the highest DHS compared to those with lower DHS in the

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Table 2
Baseline participants' characteristics based on quartiles of the dietary habits score.

Variable	Quartiles of dietary habits score				P value
	Q1	Q2	Q3	Q4	
Age (year)	43.4 ± 12.7[a]	44.9 ± 14.7	42.8 ± 16.1	42.8 ± 15.3	0.508
Weight (Kg)	69.8 ± 12.2	68.9 ± 12.7	68.5 ± 11.9	67 ± 12.6	0.238
BMI (Kg/m^2)	25.4 ± 4.1	25.1 ± 4.2	24.9 ± 4.2	24.4 ± 4.3	0.236
Systolic blood pressure (mmHg)	122.7 ± 12.6	121.8 ± 12.4	123.5 ± 14.7	121.2 ± 12.1	0.38
Diastolic blood pressure (mmHg)	80.4 ± 7.6	79.3 ± 6.8	80.6 ± 8.1	79.4 ± 7.5	0.251
Fasting blood glucose (mg/dL)	87.8 ± 26.4	89.3 ± 24.6	85.8 ± 18	87.9 ± 28.5	0.608
Triglyceride (mg/dL)	130 ± 59.2	129 ± 70.7	126.6 ± 68	128.7 ± 83.9	0.974
HDL-cholesterol (mg/dL)	56.4 ± 14.6	56.6 ± 12	58.5 ± 14.7	57.4 ± 12.3	0.456
Waist circumference (cm)	90.2 ± 11.3	88.9 ± 10.3	88.5 ± 11.4	88 ± 11.6	0.312
Sex (%)					
Male	52.4	53.6	56.8	55.8	0.831
Female	47.6	46.4	43.2	44.2	
Current smokers (%)	12.9	18.1	20.8	17.2	0.277
Economic Status (%)					
Low	19.3	29.4	19.5	33.3	0.54
Moderate	39.8	31.8	45.1	47.4	
High	40.9	38.8	35.4	19.3	
Physical activity (%)					
Low	52.2	66.4	60.3	60.6	0.518
Moderate	40.9	29.9	33.1	33.9	
Vigorous	7	3.7	6.6	5.5	
Education (%)					
Primary	46.4	45.3	46.3	53.5	0.027
High school	36.1	39	44	40.7	
Academic	17.5	15.7	9.7	5.8	

[a] Values are mean ± standard deviation, otherwise indicated.

crude (P = 0.028) and the multivariable adjusted models (P = 0.013). Furthermore, women with highest DHS values experienced a marginally significant decrease in serum HDL cholesterol levels (P = 0.065) in the crude model. The association became significant after adjustment for age, smoking status, economic status, physical activity and education (P = 0.002). There was also a significant association between mean changes of waist circumference and quartiles of dietary habits score in men only in the fully adjusted model (P = 0.029). When the associations were examined in the total population, it was revealed that participant were not different in mean MetS components at baseline and at the follow-up as well as in the change values according to quartiles of DHS.

The Risk of developing MetS and its components according to quartiles of DHS for the total population is reported in Table 4. The analyses revealed that the risk of abdominal obesity [Hazard Ratio (HR) = 3.43, 95% confidence interval (CI): 1.97–5.94], low HDL cholesterol (HR = 3.01, 95%CI: 1.62–5.62), hyperglycemia (HR = 3.06, 95%CI: 1.58–5.94) and hypertension (HR = 3.44, 95%CI: 1.85–6.37) is significantly higher in those with the highest DHS compared with subjects with the lowest scores in the crude and multivariable adjusted models; furthermore, there was a linear trend between the dietary habit score and the risk of developing MetS components (P < 0.05). There were not any statically significant association between quartiles of dietary habits score and the risk of hypertriglyceridemia (P > 0.05). The analysis of the association between dietary habits score and the risk of MetS revealed that after adjustment for all possible confounders, the participants with the highest dietary habits score (quartile 4) had 40 percent higher risk for developing MetS (95% CI:1.06–1.9) in the crude model. After adjustment for confounders in the fully adjusted model, subjects in the highest quartile of DHS had a 2.94 times higher risk (95%CI: 1.6–5.39) for developing the disease compared to those who had the least scores. The linear trend between DHS score and the risk of MetS was also significant in the crude and multivariable adjusted models (P < 0.05, Table 4).

The analyses revealed that the risk of hyperglycemia (HR = 2.49, 95%CI: 1.12–5.58), hypertension (HR = 4.36, 95%CI: 2.14–8.91), low HDL cholesterol (HR = 2.89, 95%CI: 1.27–6.58), and abdominal obesity (HR = 3.99, 95%CI: 1.96–8.12) is significantly higher in men with the highest dietary habit score compared to subjects with the lowest scores either in crude and multivariable adjusted models (Table 5). The analysis of the association between dietary habits score and risk of MetS in men revealed that after adjustment for all possible confounders the participants with the highest dietary habits sore (quartile 4) had a 3.1 times higher risk (95%CI: 1.48–6.5) for developing the disease compared to those who had the least scores. The risk of MetS increased as the dietary habits score increased in men (P < 0.05). Although the risk of hypertriglyceridemia, low HDL cholesterol levels and MetS were not significantly associated with DHS quartiles, however, the trend became significant after adjustment for all possible confounders, in women (P < 0.05). The DHS was not associated with other MetS components in women (Table 5).

4. Discussion

In this cohort study of Iranian adults, we found a significant association between DHS and the risk for developing MetS after adjustment for all potential confounder; as subjects in the highest quartile of DHS had higher risk for developing the disease compared to those with the lowest scores. Also, the risk of abdominal obesity, low HDL cholesterol, hyperglycemia, and hypertension was significantly higher in those in the highest quartiles of DHS in total population, and after gender stratified analysis in men.

In the previous study, we investigated the association between each dietary habit and MetS risk [24]. Although we could not find a significant association between individual dietary habits and MetS and its components, the present study revealed that the overall dietary habits score was strongly associated with the disease risk. Eating salad was one of the components of the dietary behavior scoring system in the current investigation. Some studies reported that eating salad and consumption of vegetables might decrease the risk of MetS [30–32]. Also, a study that was done in Iran

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Table 3
Components of Metabolic syndrome at baseline and follow-up as well as their change according to quartiles of dietary habits score in men, women and the total population.

Components of MetS		Dietary habits score (men)					Dietary habits score (women)					Dietary habits score (total population)				
		Q1	Q2	Q3	Q4	*P*	Q1	Q2	Q3	Q4	*P*	Q1	Q2	Q3	Q4	*P*
Median Dietary habits score		11.1	11.8	12.52	13.42		9.52	10	10.26	11.16		13	13.47	13.91	14.41	
Fasting blood sugar (mg/dl)																
Baseline		93.2 ± 2.5[a]	87.1 ± 2.5	88.2 ± 2.5	85.6 ± 2.5	0.161	87.2 ± 2.4	84.5 ± 2.5	87.1 ± 2.4	86.1 ± 2.4	0.845	87.8 ± 1.9	89.3 ± 1.9	85.8 ± 1.8	87.9 ± 1.9	0.608
After		103.7 ± 3	107.7 ± 3.1	106.9 ± 3.1	103.6 ± 3.2	0.708	100.9 ± 3.6	99.7 ± 3.7	106.3 ± 3.8	103.4 ± 3.6	0.619	103.1 ± 2.5	106.1 ± 2.6	104.4 ± 2.5	105.2 ± 2.7	0.859
Change	Crude	10 ± 3.3	19.9 ± 3.4	20.6 ± 3.4	17.4 ± 3.6	0.102	14.2 ± 3.6	14.8 ± 3.8	19.7 ± 3.8	16 ± 3.6	0.738	14.6 ± 2.6	16.6 ± 2.7	19.8 ± 2.6	16.2 ± 2.8	0.569
	Model I[b]	10.2 ± 3.4	19.9 ± 3.4	20.6 ± 3.4	17.3 ± 3.6	0.122	13.8 ± 3.6	14.7 ± 3.8	19.5 ± 3.8	16.6 ± 3.7	0.722	14.6 ± 2.6	16.6 ± 2.7	19.8 ± 2.6	16.2 ± 2.8	0.571
	Model II[c]	11.9 ± 4.2	22.6 ± 4.4	19.5 ± 4.9	23.9 ± 6.1	0.266	15.8 ± 4	17.1 ± 3	6.3 ± 4.4	9.3 ± 3.3	0.125	15.9 ± 3.3	13 ± 3.4	15.4 ± 3.5	26 ± 4.3	0.115
Systolic blood pressure (mm Hg)																
Baseline		126.5 ± 1.3	123.9 ± 1.3	124.3 ± 1.3	122.6 ± 1.3	0.205	120.1 ± 1.3	120.8 ± 1.4	120.9 ± 1.3	116.3 ± 1.4	0.050	122.7 ± 1	121.8 ± 1	123.5 ± 1	121.2 ± 1	0.38
After		128.3 ± 7.2	134.4 ± 7.1	132.9 ± 7.2	135.1 ± 7.6	0.91	123.9 ± 2.3	121.5 ± 2.4	124.8 ± 2.4	115.1 ± 2.3	0.018	125.3 ± 4.2	129 ± 4.3	129 ± 4.1	128.3 ± 4.6	0.918
Change	Crude	1.1 ± 7.2	10.5 ± 7.1	9.5 ± 7.2	11.8 ± 7.6	0.721	4.4 ± 2	0.9 ± 2.1	2.7 ± 2.1	−0.1 ± 2	0.422	2.1 ± 4.1	7.2 ± 4.2	5.9 ± 4.1	6.9 ± 4.6	0.817
	Model I[b]	0.12 ± 7.2	11 ± 7.1	9.6 ± 7.2	12.3 ± 7.6	0.632	3.8 ± 2	0.7 ± 2.1	2.4 ± 2.1	1 ± 2	0.677	1.9 ± 4.1	7.1 ± 4.2	6 ± 4.1	7 ± 4.6	0.802
	Model II[c]	−10.7 ± 15.9	−0.07 ± 15.3	35 ± 17.3	45.2 ± 21	0.121	3.1 ± 4.5	2.4 ± 3.6	−1.4 ± 4.7	4.8 ± 3.7	0.787	−3.3 ± 11.7	−0.6 ± 11.3	20.3 ± 11.7	25.7 ± 14	0.263
Diastolic blood pressure (mm Hg)																
Baseline		81.9 ± 0.8	80.7 ± 0.8	81.1 ± 0.8	80.7 ± 0.8	0.682	79.4 ± 0.8	79.1 ± 0.8	78.7 ± 0.7	77.1 ± 0.8	0.131	80.4 ± 0.6	79.3 ± 0.6	80.6 ± 0.5	79.4 ± 0.6	0.251
After		79.6 ± 2.2	80.7 ± 2.2	82.5 ± 2.2	78.6 ± 2.4	0.664	81.9 ± 2.7	78.1 ± 2.9	84.8 ± 2.9	77.8 ± 2.8	0.27	79.9 ± 1.9	81.5 ± 1.9	80.3 ± 1.8	81.8 ± 2.1	0.889
Change	Crude	−2.9 ± 2.3	−0.07 ± 2.3	1.3 ± 2.3	−2±2.5	0.573	2.7 ± 2.7	−0.9 ± 2.9	6.1 ± 2.9	0.9 ± 2.8	0.367	−0.9 ± 1.9	2.2 ± 1.9	0.01 ± 1.9	2.2 ± 2.1	0.571
	Model I[b]	−2.6 ± 2.3	−0.2 ± 2.3	1.3 ± 2.3	−2.2 ± 2.5	0.619	2.2 ± 2.7	−1.1 ± 2.9	5.8 ± 2.9	1.9 ± 2.8	0.413	−1.1 ± 1.9	2.2 ± 1.9	0.06 ± 1.9	2.4 ± 2.1	0.527
	Model II[c]	−6.1 ± 2.2	0.01 ± 2.1	1.6 ± 2.4	−1.5 ± 2.9	0.106	5.1 ± 3	0.9 ± 2.4	0.1 ± 3.1	0.5 ± 2.5	0.605	−0.3.1 ± 1.8	−0.77 ± 1.8	0.04 ± 1.8	0.08 ± 2.2	0.614
Serum triglyceride(mg/dl)																
Baseline		124.3 ± 8	138.2 ± 8.1	133.7 ± 8	145.4 ± 8	0.306	130.8 ± 5.9	121.1 ± 6.1	118.3 ± 5.8	105.4 ± 5.9	0.027	130 ± 5.4	129.2 ± 5.5	126.6 ± 5.2	128.7 ± 5.5	0.974
After		135.9 ± 8.3	148.6 ± 8.4	143.7 ± 8.6	154.4 ± 8.9	0.477	129.8 ± 6.3	122.7 ± 6.6	130.1 ± 6.7	127.9 ± 6.3	0.844	134.8 ± 5.6	135.7 ± 5.9	138 ± 5.6	144.7 ± 6.1	0.637
Change	Crude	7.4 ± 7.9	8.5 ± 7.9	17.5 ± 8.1	10.7 ± 8.4	0.812	−0.7 ± 6	4.8 ± 6.3	8.4 ± 6.4	24.2 ± 6.1	0.028	3.6 ± 5.3	4.9 ± 5.5	14.5 ± 5.3	17.9 ± 5.7	0.179
	Model I[b]	11.6 ± 7.6	7 ± 7.6	16.2 ± 7.8	9 ± 8	0.85	−0.5 ± 6.1	4.9 ± 6.3	8.5 ± 6.4	23.9 ± 6.1	0.036	4.7 ± 5.2	5.4 ± 5.4	13.6 ± 5.2	16.9 ± 5.6	0.295
	Model II[c]	8.3 ± 10.3	−4.6 ± 10.6	1 ± 11.8	−2.6 ± 14.8	0.839	−1.9 ± 15	−4.7 ± 11.4	45.4 ± 16.5	25.6 ± 12.3	0.013	4.8 ± 8.4	1.8 ± 8.8	1 ± 8.8	2.4 ± 10.9	0.991
Serum High density lipoprotein cholesterol (mg/dl)																
Baseline		56.2 ± 1.2	52.7 ± 1.3	55 ± 1.3	56.8 ± 1.3	0.123	59.6 ± 1.5	56.1 ± 1.5	59.7 ± 1.5	60.8 ± 1.5	0.15	56.4 ± 1	56.6 ± 1	58.5 ± 1	57.4 ± 1	0.456
After		39.9 ± 0.7	38.6 ± 0.7	38.8 ± 0.8	40.1 ± 0.8	0.372	44.3 ± 0.9	45.3 ± 1	45.5 ± 1	44.1 ± 1	0.67	42.7 ± 0.6	41.4 ± 0.7	42.2 ± 0.6	41 ± 0.7	0.278
Changes	Crude	−15.8 ± 1.2	−13.6 ± 1.3	−15.9 ± 1.3	−17.2 ± 1.3	0.269	−13.4 ± 1.5	−10.9 ± 1.6	−13.9 ± 1.6	−16.8 ± 1.5	0.065	−13.3 ± 1	−14.4 ± 1	−15.8 ± 1	−16.4 ± 1	0.141
	Model I[b]	−15.8 ± 1.3	−13.6 ± 1.3	−15.9 ± 1.3	−17.2 ± 1.3	0.27	−13.2 ± 1.5	−10.8 ± 1.6	−13.9 ± 1.6	−17.2 ± 1.5	0.041	−13.3 ± 1	−14.3 ± 1.1	−15.8 ± 1	−165 ± 1.1	0.141
	Model II[c]	−14.9 ± 1.9	−12.6 ± 1.9	−12.1 ± 2.2	−20.1 ± 2.7	0.89	−8.5 ± 3.4	−0.3 ± 2.6	−9.7 ± 3.7	−15.8 ± 2.8	0.002	−10.1 ± 1.7	−12.5 ± 1.8	−11.4 ± 1.8	−17 ± 2.2	0.101
Waist circumference (cm)																
Baseline		89.8 ± 1.1	89.5 ± 1.1	86.8 ± 1.1	88.1 ± 1.1	0.177	89.1 ± 1.2	89.9 ± 1.3	89.2 ± 1.2	88 ± 1.3	0.77	90.2 ± 0.8	88.9 ± 0.9	88.5 ± 0.8	87.9 ± 0.9	0.312
After		96.4 ± 1.2	97.8 ± 1.2	96.4 ± 1.2	97.3 ± 1.3	0.816	100.6 ± 1.3	99.4 ± 1.4	101.2 ± 1.4	98.8 ± 1.3	0.593	98.8 ± 0.9	97.6 ± 1	98 ± 0.9	99 ± 1	0.69
Change	Crude	6.7 ± 0.9	8 ± 0.9	9.7 ± 0.9	9 ± 1	0.122	11.7 ± 1.2	9.5 ± 1.3	12.3 ± 1.3	11.3 ± 1.2	0.439	8.7 ± 0.8	8.8 ± 0.8	9.6 ± 0.8	11 ± 0.9	0.201
	Model I[b]	7.2 ± 0.8	7.9 ± 0.8	9.5 ± 0.9	8.7 ± 0.9	0.258	12 ± 1.2	9.6 ± 1.2	9.6 ± 1.2	12.5 ± 1.2	0.337	8.8 ± 0.7	9 ± 0.8	9.5 ± 0.8	10.8 ± 0.8	0.289
	Model II[c]	5.7 ± 1.3	6.8 ± 1.3	11.2 ± 1.5	5.4 ± 1.9	0.029	11.3 ± 2.9	9.1 ± 2.2	9.9 ± 3	11.3 ± 2.3	0.893	6.6 ± 1.2	7.6 ± 1.3	9.4 ± 1.3	8.7 ± 1.6	0.462

[a] Values are presented as mean ± standard error.
[b] Model I: Adjusted for age and sex.
[c] Model II: Adjusted for age, sex, smoking, economic status, physical activity and education.

Table 4
Hazard ratio and its corresponding 95% confidence interval for developing MetS and its components according to quartiles of dietary habits score in the total population.

	Dietary habits score				
	Q1	Q2	Q3	Q4	P for trend
Hyperglycemia					
Crude	1	1.36 (0.96–1.92)	0.27 (0.9–1.79)	1.53 (1.1–2.17)	0.028
Model I[a]	1	1.31 (0.93–1.84)	1.3 (0.93–1.84)	1.57 (1.11–2.22)	0.015
Model II[b]	1	1.45 (0.77–2.75)	1.58 (0.84–2.99)	3.06 (1.58–5.94)	0.002
Hypertension					
Crude	1	1.44 (1.05–1.96)	1.2 (0.87–1.65)	1.42 (1.03–1.97)	0.09
Model I[a]	1	1.29 (0.94–1.77)	1.2 (0.87–1.65)	1.41 (1.01–1.95)	0.071
Model II[b]	1	1.74 (0.98–3.09)	1.78 (0.998–3.19)	3.44 (1.85–6.37)	0.0001
Hypertriglyceridemia					
Crude	1	1.05 (0.74–1.47)	1.15 (0.83–1.5)	1.27 (0.9–1.78)	0.143
Model I[a]	1	1.01 (0.72–1.43)	1.16 (0.84–1.62)	1.28 (0.91–1.8)	0.113
Model II[b]	1	1.87 (0.98–3.56)	1.64 (0.84–3.19)	2.04 (0.92–4.56)	0.073
Low high density lipoprotein (HDL) cholesterol levels					
Crude	1	1.42 (1.07–1.86)	1.31 (0.99–1.72)	1.45 (1.09–1.93)	0.02
Model I[a]	1	1.37 (1.04–1.81)	1.3 (0.98–1.71)	1.41 (1.06–1.88)	0.028
Model II[b]	1	2.4 (1.43–4)	1.83 (1.06–3.17)	3.01 (1.62–5.62)	0.002
Abdominal obesity					
Crude	1	1.31 (1.02–1.69)	1.24 (0.97–1.6)	1.45 (1.12–1.89)	0.009
Model I[a]	1	1.27 (0.98–1.64)	1.28 (0.99–1.65)	1.43 (1.1–1.86)	0.007
Model II[b]	1	2.08 (1.27–3.4)	1.78 (1.09–2.9)	3.43 (1.97–5.94)	0.0001
Metabolic syndrome					
Crude	1	1.3 (0.97–1.73)	1.2 (0.9–1.6)	1.4 (1.06–1.9)	0.036
Model I[a]	1	1.24 (0.93–1.65)	1.22 (0.91–1.62)	1.42 (1.06–1.9)	0.027
Model II[b]	1	1.84 (1.08–3.15)	1.87 (1.08–3.2)	2.94 (1.6–5.39)	0.001

[a] Model I: Adjusted for age and sex.
[b] Model II: Adjusted for age, sex, smoking, economic status, physical activity and education.

showed that the risk of MetS might be reduced by 30% in subjects who consumed more vegetables compared to subjects with lower consumption of vegetables [33]. Vegetables with having antioxidants, low fibers, low calories might reduce inflammatory markers and decrease obesity, diabetes, and also the risk of MetS [33,34]. Adding salt to food at the table and using special measuring cup for adding salt to food when cooking were other components of DHS in the present study. Other studies reported that high-salt diets and lack of using special measuring cup for adding salt to food when cooking might increase the risk of MetS [35]. Conversion of glucose into lipids by activating lipogenic enzymes, increasing the metabolism of lipids, and developing insulin resistance are proposed mechanisms by which high-salt diets might increase the risk of MetS [36,37]. Also, its reported that the body sodium content increases by the number of Mets components [38].

In the current study cutting the skin off when eating poultry, usual use of frying for cooking, removing the visible fat from meat when cooking, and using special measuring cup for adding oil to

Table 5
Hazard ratio and its corresponding 95% confidence interval for developing MetS and its components according to quartiles of dietary habits score in men and women.

	Dietary habits score in men					Dietary habits score in women				
	Q1	Q2	Q3	Q4	P for trend	Q1	Q2	Q3	Q4	P for trend
Hyperglycemia										
Crude	1	1.45 (0.94–2.25)	1.94 (1.26–2.97)	1.62 (1.03–2.55)	0.011	1	0.65 (0.39–1.07)	0.66 (0.4–1.08)	0.83 (0.51–1.35)	0.47
Model I[a]	1	1.52 (0.98–2.35)	2.09 (1.36–3.21)	1.66 (1.062.62)	0.007	1	0.56 (0.33–0.95)	0.59 (0.36–0.98)	0.9 (0.55–1.47)	0.65
Model II[b]	1	1.32 (0.66–2.65)	3.13 (1.55–6.33)	2.49 (1.12–5.58)	0.003	1	1.11 (0.21–5.88)	1.47 (0.25–8.52)	2.04 (0.36–11.42)	0.287
Hypertension										
Crude	1	1.47 (0.97–2.22)	1.39 (0.9–2.15)	1.68 (1.09–2.58)	0.028	1	0.71 (0.47–1.1)	0.64 (0.42–0.98)	0.73 (0.47–1.14	0.127
Model I[a]	1	1.57 (1.04–2.38)	1.54 (0.99–2.4)	1.71 (1.11–2.64)	0.017	1	0.57 (0.37–0.89)	0.54 (0.35–0.83)	0.82 (0.53–1.28)	0.26
Model II[b]	1	1.57 (0.82–3.03)	2.58 (1.26–1.26-5.32)	4.36 (2.14–8.91)	0.0001	1	0.98 (0.29–3.3)	1.13 (0.3–4.22)	1.65 (0.45–6.02)	0.34
Hypertriglyceridemia										
Crude	1	1.26 (0.79–2)	1.75 (1.12–2.75)	1.95 (1.24–3.07)	0.001	1	0.68 (0.42–1.11)	0.82 (0.52–1.29)	0.77 (0.47–1.25)	0.443
Model I[a]	1	1.26 (0.79–2)	1.76 (1.12–2.78)	1.95 (1.24–3.07)	0.001	1	0.57 (0.35–0.94)	0.72 (0.45–1.14)	0.86 (0.53–1.4)	0.704
Model II[b]	1	1.61 (0.77–3.4)	2.61 (1.2–5.71)	2.2 (0.85–5.69)	0.02	1	3.81 (0.44–33.3)	8.29 (0.96–71.3)	7.5 (0.83–68.2)	0.025
Low high density lipoprotein (HDL) cholesterol levels										
Crude	1	1.77 (1.18–2.65)	2.23 (1.49–3.34)	1.94 (1.26–2.99)	0.001	1	0.69 (0.47–0.99)	0.68 (0.48–0.96)	0.92 (0.65–1.29)	0.625
Model I[a]	1	1.8 (1.2–2.7)	2.35 (1.56–3.53)	1.97 (1.28–3.02)	0.0001	1	0.68 (0.47–0.97)	0.67 (0.47–0.95)	0.93 (0.66–1.3)	0.972
Model II[b]	1	2.34 (1.24–4.4)	3.12 (1.54–6.32)	2.89 (1.27–6.58)	0.001	1	0.92 (0.35–2.45)	1.65 (0.61–4.49)	2.08 (0.82–5.27)	0.029
Abdominal obesity										
Crude	1	1.58 (1.1–2.27)	1.9 (1.31–2.76)	2.01 (1.38–2.93)	0.0001	1	0.83 (0.59–1.16)	0.83 (0.59–1.16)	0.84 (0.6–1.17)	0.34
Model I[a]		1.7 (1.18–2.44)	2.12 (1.45–3.1)	2.11 (1.44–3.08)	0.0001	1	0.81 (0.58–1.14)	0.82 (0.58–1.16)	0.88 (0.63–1.23)	0.488
Model II[b]	1	1.57 (0.88–2.8)	2.47 (1.32–4.63)	3.99 (1.96–8.12)	0.0001	1	0.79 (0.33–1.89)	1.3 (0.5–3.35)	1.2 (0.5–2.89)	0.34
Metabolic syndrome										
Crude	1	1.57 (1.05–2.33)	1.996 (1.34–2.96)	1.86 (1.23–2.8)	0.001	1	0.68 (0.45–1.01)	0.7 (0.49–1.04)	0.82 (0.56–1.2)	0.4
Model I[a]	1	1.62 (1.09–2.4)	2.14 (1.44–3.18)	1.89 (1.25–2.8)	0.001	1	0.6 (0.4–0.9)	0.65 (0.44–0.96)	0.89 (0.6–1.31)	0.584
Model II[b]	1	1.83 (0.99–3.38)	2.93 (1.49–5.7)	3.1 (1.48–6.5)	0.0001	1	1.71 (0.45–6.4)	2.61 (0.67–10.1)	3.76 (0.99–1.09)	0.021

[a] Model I: Adjusted for age and sex.
[b] Model II: Adjusted for age, sex, smoking, economic status, physical activity and education.

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food were also used for assessing the DHS. Previous investigations have shown that high-fat foods and fried foods might develop insulin resistance, and subsequently increase the risk of MetS [39,40]. Also, lipid profile might be affected by consuming high fat diet, and subsequently it could lead to increased waist circumference and the risk of MetS [41]. Eating fast foods was another component of DHS in the study. Some studies reported that eating fast food might increase the risk of abdominal obesity [42,43]. Furthermore, fast foods have high content of fat, salt, sugar, energy density, and they are low in fiber; therefore, they increase the risk of abdominal obesity and MetS [44,45]. Moreover, it seems that due to lack of control in salt intake, dining out could increase the risk of blood pressure and consequently, increase the risk of MetS [42,46]. Finally, lack of paying attention to food labels before buying and consuming foods which was another component of DHS, was shown to increase the risk of all components of MetS [47]. However, to the best our knowledge, there were no studies taking all dietary habits into account using a scoring system and assess its association with the risk of MetS and its components.

In line with our study, a number of studies found that unhealthy dietary behaviors score increased triglyceride levels [48,49], but unlike to the current study, there was no significant difference in triglyceride levels and nutritional risk scores between groups in another study [50].

As the current study reported the increased risk of abdominal obesity in the highest quartile of DHS, other studies reported that having unhealthy dietary behaviors is associated with increased abdominal obesity. High-fat foods, refines grains, large carbohydrates intake with large portion size and overall energy intake are characteristics of unhealthy dietary behaviors that cause abdominal obesity [51–53]. Also, similar to our results, a cross-sectional study on 3177 participants from the Framingham Heart Study Offspring Cohort reported that the participants in the highest of the 2005 Dietary Guidelines for Americans Index (DGAI) score, who had healthier diet choices, had significantly lower risk of abdominal obesity after adjustment for potential confounders such as age, sex, smoking, physical activity and also using multivitamin and energy intake [54].

We found that the risk of hyperglycemia was more than 3 times for total population after adjustment for potential confounders in those with highest DHS compared to those with lowest DHS score. Also, other studies have reported the association between unhealthy or western dietary pattern score and increased risk of hyperglycemia [55,56].

We found that the risk of low HDL cholesterol was associated with quartiles of DHS in total population and men, but not in women. The difference in men and women might be explained by having different dietary habits between them [57], as the current study showed different DHS between male and female participants. Similar to our study, another study showed that, high healthy food habit scores was associated with low HDL cholesterol levels [58].

The strengths of the our research might be that the study was the first one trying to develop an evidence based dietary habits score and examining its association with the risk of hyperglycemia, hypertension, hypertriglyceridemia, low HDL cholesterol, abdominal obesity and MetS in adults. Developing this scoring method enables us to look into the association between overall not only one dietary habit in association with chronic diseases. We tried to develop the DHS based on the risk estimates that was previously derived for each dietary habit in the population [24]; therefore, this scoring method might provide more realistic risk estimates for the association between overall dietary habits and MetS. Also, we tried to adjust all potential confounders (including age, sex, smoking, socioeconomic status, physical activity and education) that might affect the association between dietary habits scoring and the risk of MetS. In a previous study it was shown that there was a significant association between socioeconomic status and the development of MetS in this population [7]. In the other word, participants with high level of socioeconomic status had more chance for developing MetS compared to participants with low level of socioeconomic status. There were no significant association between physical activity and development of MetS. Furthermore, the risk of MetS was lower in those with academic education compared to those with primary education [7].

A number of limitations should be taken into account when interpreting our results: 1) in the present study, 25.9% of participants without MetS at the baseline were lost at follow-up phase. Migration, mortality, disability, and no response to the phone calls were the main causes of the loss to follow-up. 2) In the study, repeated measurement was done after about 10 years and as a result, the exact time for the occurrence of MetS was not clear for each participant. Omission of the exact time for occurrence of the MetS might bias the result. 3) The dietary assessment including the caloric intake was not accomplished at the first phase of the current study; therefore, we were not able to adjust the possible dietary confounders like the energy intake for the association between dietary habits and MetS.

In conclusion, to our knowledge, this was the first study examining a dietary habits score in association with the risk of hyperglycemia, hypertension, hypertriglyceridemia, low HDL cholesterol, abdominal obesity and MetS in Iranian adults. This study provides evidence that the highest quartile of DHS is significantly associated with increased risk of hyperglycemia, hypertension, low HDL cholesterol, abdominal obesity and men in the total population as well as men. The trend for all of these associations was significant for total population and men. The trend for the association between DHS and hypertriglyceridemia, low HDL cholesterol and MetS was also significant in women. Further studies are recommended to confirm the approach used to calculate the DHS and its association with the risk of MetS and its components in other populations.

Authors' contribution

The authors' responsibilities were as follows: Study concept and design: Mirhosseini, Sarebanhassanabadi, Namayandeh, Mirzaei, Soltani, and Salehi-Abargouei. Sampling: Sarebanhassanabadi, Namayandeh. Statistical analysis: Salehi-Abargouei, Sarebanhassanabadi. Drafting of the manuscript: Sarebanhassanabadi and Salehi-Abargouei. Critical revision of the manuscript for important intellectual content: Sarebanhassanabadi, Mirzaei, Namayandeh, Salehi-Abargouei. All authors confirmed the final draft of the manuscript.

Conflict of interest

All of authors declare that there was no conflict of interest for the present study.

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References

[1] Amiri P, Deihim T, Hosseinpanah F, Barzin M, Hasheminia M, Montazeri A, et al. Diagnostic values of different definitions of metabolic syndrome to

detect poor health status in Iranian adults without diabetes. Diabet Med–J British Diabet Assoc 2014;31:854–61.
[2] Cheung BM, Wat NM, Tam S, Thomas GN, Leung GM, Cheng CH, et al. Components of the metabolic syndrome predictive of its development: a 6-year longitudinal study in Hong Kong Chinese. Clin Endocrinol 2008;68:730–7.
[3] Li R, Li W, Lun Z, Zhang H, Sun Z, Kanu JS, et al. Prevalence of metabolic syndrome in mainland China: a meta-analysis of published studies. BMC Public Health 2016;16:1.
[4] Zabetian A, Hadaegh F, Azizi F. Prevalence of metabolic syndrome in Iranian adult population, concordance between the IDF with the ATPIII and the WHO definitions. Diabetes Res Clin Pract 2007;77:251–7.
[5] Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi F. Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. Am J Clin Nutr 2005;82:523–30.
[6] Shahvazi S, Nadjarzadeh A, Mehri Z, Salehi-Abargouei A. Prevalence of metabolic syndrome in adult females: comparison between Iranian national definition and currently used international criteria. Journal of Nutr Food Secur 2016;1:49–62.
[7] Sarebanhassanabadi M, Jalil Mirhosseini S, Mirzaei M, Namayandeh SM, Soltani MH, Pedarzadeh A, et al. The incidence of metabolic syndrome and the most powerful components as predictors of metabolic syndrome in Central Iran: a 10-year follow-up in a cohort study. Iran Red Crescent Med J 2017;19:e14934.
[8] Lin E, Kuo PH, Liu YL, Yang AC, Kao CF, Tsai SJ. Effects of circadian clock genes and health-related behavior on metabolic syndrome in a Taiwanese population: evidence from association and interaction analysis. PLoS One 2017;12:e0173861.
[9] Azadbakht L, Mirmiranr R, Azizi F. Predictors of cardiovascular risk factors in Tehranian adults: diet and lifestyle. East Mediterr Health J = La revue de sante de la Mediterranee orientale = al-Majallah al-sihhiyah li-sharq al-mutawassit 2006;12:88–97.
[10] Ponciano-Rodriguez G, Paez-Martinez N, Villa-Romero A, Gutierrez-Grobe Y, Mendez-Sanchez N. Early changes in the components of the metabolic syndrome in a group of smokers after tobacco cessation. Metab Syndrome Relat Disord 2014;12:242–50.
[11] Babio N, Bulló M, Salas-Salvadó J. Mediterranean diet and metabolic syndrome: the evidence. Publ Health Nutr 2009;12:1607–17.
[12] Mendez-Hernandez P, Dosamantes-Carrasco LD, Siani C, Pierlot R, Martinez-Gomez M, Rivera-Paredez B, et al. Mealtime habits and risk of developing the metabolic syndrome or insulin resistance among Mexican adults. Br J Nutr 2016:1–10.
[13] Shimokata H. Dietary habit and longevity. Nihon Ronen Igakkai zasshi Japanese journal of geriatrics 2007;44:209–11.
[14] Wennberg M, Gustafsson PE, Wennberg P, Hammarstrom A. Poor breakfast habits in adolescence predict the metabolic syndrome in adulthood. Publ Health Nutr 2015;18:122–9.
[15] Mobarakeh ZS, Mirzaei K, Hatmi N, Ebrahimi M, Dabiran S, Sotoudeh G. Dietary habits contributing to breast cancer risk among Iranian women. Asian Pac J Cancer Prev APJCP 2014;15:9543–7.
[16] Dietary habits. In: Preedy V, Watson R, editors. Handbook of disease burdens and quality of life measures. New York: Springer; 2010. p. 4189.
[17] Shin A, Lim S-Y, Sung J, Shin H-R, Kim J. Dietary intake, eating habits, and metabolic syndrome in Korean men. J Am Diet Assoc 2009;109:633–40.
[18] bin Zaal AA, Musaiger AO, D'Souza R. Dietary habits associated with obesity among adolescents in Dubai, United Arab Emirates. Nutr Hosp 2009;24:437–44.
[19] Boumtje PI, Huang CL, Lee J-Y, Lin B-H. Dietary habits, demographics, and the development of overweight and obesity among children in the United States. Food Policy 2005;30:115–28.
[20] Panagiotakos DB, Tzima N, Pitsavos C, Chrysohoou C, Papakonstantinou E, Zampelas A, et al. The relationship between dietary habits, blood glucose and insulin levels among people without cardiovascular disease and type 2 diabetes; the ATTICA study. Rev Diabet Stud 2005;2:208–15.
[21] Conroy RM, Pyorala K, Fitzgerald AP, Sans S, Menotti A, De Backer G, et al. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J 2003;24:987–1003.
[22] Panagiotakos D. Health measurement scales: methodological issues. Open Cardiovasc Med J 2009;3:160.
[23] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg 2014;12:1495–9.
[24] Sarebanhassanabadi M, Mirhosseini SJ, Mirzaei M, Namayandeh SM, Soltani MH, Pakseresht M, et al. Effect of dietary habits on the risk of metabolic syndrome: Yazd Healthy Heart Project. Publ Health Nutr 2017:1–8.
[25] Chackrewarthy S, Gunasekera D, Pathmeswaren A, Wijekoon C, Ranawaka U, Kato N, et al. A comparison between revised NCEP ATP III and IDF definitions in diagnosing metabolic syndrome in an urban Sri Lankan population: the Ragama health study. ISRN endocrinology 2013;2013.
[26] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart association/national Heart, lung, and blood institute scientific statement. Circulation 2005;112:2735–52.
[27] Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech 2009;2:231–7.
[28] Esteghamati A, Ashraf H, Rashidi A, Meysamie A. Waist circumference cut-off points for the diagnosis of metabolic syndrome in Iranian adults. Diabetes Res Clin Pract 2008;82:104–7.
[29] Maddison R, Ni Mhurchu C, Jiang Y, Vander Hoorn S, Rodgers A, Lawes CMM, et al. International physical activity questionnaire (IPAQ) and New Zealand physical activity questionnaire (NZPAQ): a doubly labelled water validation. Int J Behav Nutr Phys Act 2007;4:62.
[30] Ford ES, Mokdad AH, Giles WH, Brown DW. The metabolic syndrome and antioxidant concentrations: findings from the third national health and nutrition examination survey. Diabetes 2003;52:2346–52.
[31] Yoo S, Nicklas T, Baranowski T, Zakeri IF, Yang SJ, Srinivasan SR, et al. Comparison of dietary intakes associated with metabolic syndrome risk factors in young adults: the Bogalusa Heart Study. Am J Clin Nutr 2004;80:841–8.
[32] de Oliveira E, Manda R, Torezan G, Corrente J, Burini R. Dietary, anthropometric, and biochemical determinants of plasma high-density lipoprotein-cholesterol in free-living adults. Cholesterol 2011;2011:851750.
[33] Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. Am J Clin Nutr 2006;84:1489–97.
[34] Wannamethee SG, Lowe GD, Rumley A, Bruckdorfer KR, Whincup PH. Associations of vitamin C status, fruit and vegetable intakes, and markers of inflammation and hemostasis. Am J Clin Nutr 2006;83:567–74. quiz 726-7.
[35] Baudrand R, Campino C, Carvajal CA, Olivieri O, Guidi G, Faccini G, et al. High sodium intake is associated with increased glucocorticoid production, insulin resistance and metabolic syndrome. Clin Endocrinol 2014;80:677–84.
[36] Fonseca-Alaniz MH, Brito LC, Borges-Silva CN, Takada J, Andreotti S, Lima FB. High dietary sodium intake increases white adipose tissue mass and plasma leptin in rats. Obesity 2007;15:2200–8.
[37] Oh SW, Han KH, Han SY, Koo HS, Kim S, Chin HJ. Association of sodium excretion with metabolic syndrome, insulin resistance, and body fat. Medicine 2015;94:e1650.
[38] Soltani S, Kolahdouz Mohammadi R, Shab-Bidar S, Vafa M, Salehi-Abargouei A. Sodium status and the metabolic syndrome: a systematic review and meta-analysis of observational studies. Crit Rev Food Sci Nutr 2017:1–11.
[39] Grundy SM, Abate N, Chandalia M. Diet composition and the metabolic syndrome: what is the optimal fat intake? Am J Med 2002;113:25–9.
[40] Freire RD, Cardoso MA, Gimeno SGA, Ferreira SRG. Dietary fat is associated with metabolic syndrome in Japanese Brazilians. Diabetes Care 2005;28:1779–85.
[41] Lottenberg AM, Afonso Mda S, Lavrador MS, Machado RM, Nakandakare ER. The role of dietary fatty acids in the pathology of metabolic syndrome. J Nutr Biochem 2012;23:1027–40.
[42] Bahadoran Z, Mirmiran P, Golzarand M, Hosseini-Esfahani F, Azizi F. Fast food consumption in Iranian adults; dietary intake and cardiovascular risk factors: Tehran Lipid and Glucose Study. Arch Iran Med 2012;15:346–51.
[43] Rosenheck R. Fast food consumption and increased caloric intake: a systematic review of a trajectory towards weight gain and obesity risk. Obes Rev = Off J Int Assoc Study Obes 2008;9:535–47.
[44] Duffey KJ, Gordon-Larsen P, Steffen LM, Jacobs DR, Popkin BM. Regular consumption from fast food establishments relative to other restaurants is differentially associated with metabolic outcomes in young adults. J Nutr 2009;139:2113–8.
[45] Schröder H, Fíto M, Covas MI. Association of fast food consumption with energy intake, diet quality, body mass index and the risk of obesity in a representative Mediterranean population. Br J Nutr 2007;98:1274–80.
[46] Park H-R, Jeong G-O, Lee S-L, Kim J-Y, Kang S-A, Park K-Y, et al. Workers intake too much salt from dishes of eating out and food service cafeterias; direct chemical analysis of sodium content. Nutr Res Pract 2009;3:328–33.
[47] Roberto CA, Khandpur N. Improving the design of nutrition labels to promote healthier food choices and reasonable portion sizes. Int J Obes 2014;38:S25–33.
[48] Toft U, Kristoffersen LH, Lau C, Borch-Johnsen K, Jorgensen T. The Dietary Quality Score: validation and association with cardiovascular risk factors: the Inter99 study. Eur J Clin Nutr 2007;61:270–8.
[49] Volozh O, Solodkaya E, Abina J, Kaup R, Goldsteine G, Olferiev A, et al. Some biological cardiovascular risk factors and diet in samples of the male population of Tallinn, Estonia in 1984/1985 and 1992/1993. Eur J Public Health 2002;12:16–21.
[50] Schneider RJ, Barengo N, Haapala I, Tavella M. Association between dietary habits, education, serum triglycerides and blood cholesterol among women of Cabildo. Buenos Aires Medicina = Buenos Aires- 2006;66:517.
[51] Ebbeling CB, Garcia-Lago E, Leidig MM, Seger-Shippee LG, Feldman HA, Ludwig DS. Altering portion sizes and eating rate to attenuate gorging during a fast food meal: effects on energy intake. Pediatrics 2007;119:869–75.
[52] Hooper L, Abdelhamid A, Moore HJ, Douthwaite W, Skeaff CM, Summerbell CD. Effect of reducing total fat intake on body weight: systematic review and meta-analysis of randomised controlled trials and cohort studies. BMJ 2012;345. e7666.
[53] Saneei P, Esmaillzadeh A, Keshteli AH, Feizi A, Feinle-Bisset C, Adibi P. Patterns of dietary habits in relation to obesity in Iranian adults. Eur J Nutr 2016;55:713–28.
[54] Fogli-Cawley JJ, Dwyer JT, Saltzman E, McCullough ML, Troy LM, Meigs JB, et al. The 2005 Dietary Guidelines for Americans and risk of the metabolic syndrome. Am J Clin Nutr 2007;86:1193–201.

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[55] Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. Am J Clin Nutr 2007;85:910–8.
[56] Kerver JM, Yang EJ, Bianchi L, Song WO. Dietary patterns associated with risk factors for cardiovascular disease in healthy US adults. Am J Clin Nutr 2003;78:1103–10.
[57] Vitale M, Masulli M, Cocozza S, Anichini R, Babini AC, Boemi M, et al. Sex differences in food choices, adherence to dietary recommendations and plasma lipid profile in type 2 diabetes – the TOSCA.IT study. Nutr Metabol Cardiovasc Dis 2016;26:879–85.
[58] Boucher AB, Adesanya EAO, Owei I, Gilles AK, Ebenibo S, Wan J, et al. Dietary habits and leisure-time physical activity in relation to adiposity, dyslipidemia, and incident dysglycemia in the pathobiology of prediabetes in a biracial cohort study. Metab Clin Exp 2015;64:1060–7.

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