Eur J Nutr
DOI 10.1007/s00394-014-0723-y

ORIGINAL CONTRIBUTION

Adherence to the DASH diet and prevalence of the metabolic syndrome among Iranian women

Parvane Saneei · Ebrahim Fallahi · Farzaneh Barak · Negar Ghasemifard · Ammar Hassanzadeh Keshteli · Ahmad Reza Yazdannik · Ahmad Esmaillzadeh

Received: 10 January 2014 / Accepted: 22 May 2014

Abstract
Purpose Epidemiologic data linking adherence to the dietary approaches to stop hypertension (DASH) diet and metabolic abnormalities is sparse and inconsistent. The association between habitual intake of the DASH diet and metabolic syndrome (MetS) has not been investigated in the Middle East. We aimed to determine whether usual adherence to the DASH dietary pattern was associated with MetS in a group of Iranian women.
Methods This cross-sectional study was conducted in 2012 among a representative sample of Isfahani female nurses. A validated, dish-based semiquantitative food frequency questionnaire was used for assessing usual dietary intakes. The DASH score was constructed based on 8 main foods and nutrients emphasized or minimized in the DASH diet. The MetS was defined according to the Joint Scientific Statement.
Results After controlling for potential confounders, individuals in the highest tertile of the DASH diet score had 81 % lower odds of MetS than those in the lowest category (OR 0.19; 95 % CI 0.07–0.96). Further, adjustment for body mass index slightly weakened the association (OR 0.37; 95 % CI 0.14–0.91). Participants with the greater adherence to the DASH diet were 54, 73, 78, and 80 % less likely to have enlarged waist circumference, hyperglyceridemia, low HDL-C levels, and high blood pressure, respectively, compared with those in the lowest tertile. No significant association was seen between consumption of a DASH diet and abnormal fasting plasma glucose.
Conclusions Adherence to the DASH eating plan was inversely associated with the odds of MetS and most of its features among a group of Iranian women.

Keywords DASH diet · Metabolic syndrome · Abdominal obesity · Iran

P. Saneei · F. Barak · N. Ghasemifard · A. Esmaillzadeh
Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
e-mail: saneeip@yahoo.com

P. Saneei · F. Barak · N. Ghasemifard · A. Esmaillzadeh (✉)
Department of Community Nutrition, School of Nutrition and Food Science, Isfahan University of Medical Sciences, PO Box 81745-151, Isfahan, Iran
e-mail: esmaillzadeh@hlth.mui.ac.ir

E. Fallahi
Department of Nutrition, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran

A. H. Keshteli
Integrative Functional Gastroenterology Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

A. H. Keshteli
Department of Medicine, University of Alberta, Edmonton, AB, Canada

A. R. Yazdannik
School of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran

Introduction

Metabolic syndrome (MetS), a clustering of cardiovascular risk factors, is associated with increased risk of diabetes, stroke, myocardial infarction [1], and mortality [2]. The syndrome affects 35 % of adults in the USA [3], more than 30 % of Iranian adults [4] and 10 % of adolescents [5]. The prevalence is growing in parallel with the alarming rates of obesity worldwide [4].

Published online: 07 June 2014

Earlier studies have linked dietary intakes of macronutrients, micronutrients, and individual foods to MetS [6]. Although studying individual nutrients and foods might help understanding biological mechanisms, their effects might be too small to be detected and could potentially be confounded by the effect of dietary patterns. The approach of dietary patterns offers a comprehensive and complimentary method to diet-disease relations and, in reality, is more applicable to clinical and public health interventions than food and nutrient approaches. The dietary pattern approach accounts for any interactions or synergistic effects among individual foods or nutrients [7]. Among hypothesis-oriented methods for identification of dietary patterns, the dietary approaches to stop hypertension (DASH) eating plan has received great attention. The DASH diet was first suggested for controlling blood pressure [8]; however, its beneficial effects on lipid profiles [9], diabetes [10], gestational diabetes [11], and cardiovascular disease [9, 12] have also been indicated. Since, elevated blood pressure and serum lipid concentrations are the major components of MetS, adherence to the DASH diet might also be associated with this syndrome.

Although findings from available randomized controlled trials (RCTs) have suggested favorable effects of the DASH diet on MetS [13, 14], data from observational studies are scarce. Findings from observational studies are better reflection of real-world intakes and more generalizable to the whole population than those from RCTs. Furthermore, results of RCTs cannot reflect habitual dietary intakes of population. A large body of evidence, mostly from Western countries, has been published linking DASH-like dietary pattern and metabolic abnormalities; however, data are conflicting [12, 15–17]. Some epidemiologic studies have reported that the DASH diet was associated with a lower risk of type 2 diabetes [16] and CVD risk factors [18]; however, others have documented no independent relationship between adherence to DASH guidelines and hypertension, cardiovascular mortality [12], and risk of other metabolic disorders (venous thromboembolism) [15]. In addition, some reports have supported the possibility that great adherence, as achieved in the DASH trials, may be necessary to achieve any benefits of the DASH diet [12]. Limited epidemiological data in this regard are available from developing nations [18], and to the best of our knowledge, the association between habitual intake of the DASH dietary pattern and MetS has not been investigated in the Middle East, where the dietary intakes are greatly different from those in Western countries [19]. This is particularly relevant for Iran, where the MetS has its own specific pattern. Abdominal obesity and low HDL-cholesterol levels are prevalent among two thirds of Iranian adults [19]. The aim of this study was to determine whether usual adherence to the DASH dietary pattern was associated with MetS in a group of Iranian population.

Materials and methods

Participants

This cross-sectional study was conducted in 2012 among a representative sample of Isfahani female nurses aged >30 years who were selected by a multistage cluster random sampling method. A total of seven hospitals, considering the number of public and private hospitals, were randomly selected. From female nurses working in these hospitals, 510 nurses were randomly selected and invited to participate in this study; 420 women agreed to do so. The current analysis was done on these 420 nurses. The Regional Bioethics Committee of Isfahan University of Medical Sciences approved the study protocol, and written informed consent was obtained from each participant.

Assessment of dietary intakes

We used a validated, self-administered, dish-based, machine-readable, semiquantitative food frequency questionnaire with multiple choice frequency response categories for assessing usual dietary intakes. The FFQ was a semiquantitative questionnaire containing 106 food items along with a given portion size. Foods and dishes in the FFQ were classified into five main domains to facilitate responding: (1) mixed dishes, (2) grains, (3) dairy products, (4) fruits and vegetables, and (5) miscellaneous food items and beverages. The portion sizes used in the FFQ were obtained from our earlier studies that used dietary recalls and food records. The frequency response categories for food list varied from 6 to 9 different choices from "never or less than once a month" to "12 or more times per day". The portion sizes for each food item were converted to grams using household measures. A daily value for each item was calculated based on dish composition, specified portion size, and the average of reported frequency. The food composition of mixed dishes was determined based on common recipes consumed in the country. Given the seasonal variation in dietary intakes of fruits and vegetables, the frequency response for each item was considered for the time they are available. Nutrient intakes from the FFQ were computed through linking the amounts of foods with the Nutritionist IV software, whose nutrient database was based on USDA food composition table modified for Iranian foods.

The FFQ was validated among a subsample of 200 randomly selected participants. The reliability of the FFQ was assessed by comparing dietary intakes estimated by responses to the FFQ on 2 different occasions. The validity of FFQ was assessed using the three 24-h dietary recalls as gold. Overall, these data indicated that the FFQ provides reasonably valid and reliable measures of the average long-term dietary intakes [20]. Furthermore, other studies applied this FFQ indicated that the questionnaire was relatively valid for assessment of dietary intakes [21].

The DASH score

We constructed the DASH score based on foods and nutrients emphasized or minimized in the DASH diet, focusing on 8 components: high intake of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains and low intake of sodium, sweetened beverages, and red and processed meats [22]. We calculated a DASH score for each study participant. First, participants were classified based on energy-adjusted quintile categories of their dietary intake of these components. For fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains, those in the first quintile were given the score of 1 and those in the highest quintile were given the score of 5. Other quintiles (2, 3, and 4) for these dietary intakes were given the corresponding score. For sodium, red and processed meats, and sweetened beverages, the lowest quintile was given a score of 5, and the highest quintile was given the score of 1. Those in quintiles 4, 3, and 2 for these dietary intakes were given the scores of 2, 3, and 4, respectively. Because sodium could not be measured well with the FFQ, scoring by quintiles would be least prone to misclassification rather than the use of quantitative classifications. The scores were then summed up to construct the overall DASH score that ranged from 8 to 40. Individuals with the highest DASH score were more likely to follow the DASH diet.

Assessment of covariates

Weight was measured to the nearest 100 g without shoes while wearing minimal clothes. Height was measured without shoes with shoulders in a normal position. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist circumference was measured at the narrowest level and that of the hip at the maximum level over light clothing using an un-stretched tape measure, without any pressure to body surface; measurements were recorded to the nearest 0.1 cm. In order to measure blood pressure, participants were asked to rest for 10 min. A trained nurse recorded blood pressure in a seated position, using a standard mercury sphygmomanometer. Measurements repeated after 5-min interval and the average of the two readings was considered as the subject's blood pressure. The systolic blood pressure was defined as the appearance of the first sound (Korotkoff phase 1), and the diastolic blood pressure was defined as the disappearance of the sound (Korotkoff phase 5) during deflation of the cuff at a 2–3 mm/s decrement rate of the mercury column. Fasting blood samples were drawn after a 12-h overnight fast to measure plasma glucose and serum lipid concentrations. Fasting plasma glucose was measured on the day of blood collection with an enzymatic colorimetric method using glucose oxidase. Serum triglyceride concentrations were assayed with the use of triacylglycerol kits by enzymatic colorimetric tests with glycerol phosphate oxidase. Serum levels of HDL-C were measured after precipitation of the apolipoprotein B-containing lipoproteins with phosphotungstic acid. Intra- and inter-assay CVs for all biochemical measurements were less than 10 %. Daily physical activity was assessed through the use of self-administered short form of International Physical Activity Questionnaire and was expressed as metabolic equivalent-hours per week (MET-h/week). Additional covariate information regarding age, smoking habits, socioeconomic status, marital status, menopausal situation, medical history, and current use of medications and supplements was obtained using questionnaires.

Definition of MetS

The syndrome was defined based on the presence of at least three of the following risk factors, according to the Joint Scientific Statement [23]: (1) abdominal obesity (waist circumference $\geq$ 88 cm); (2) hypertriglyceridemia (serum triglyceride levels $\geq$ 150 mg/dL); (3) low HDL-C ($<$ 50 mg/dL); (4) elevated blood pressure (systolic blood pressure $\geq$ 130 mmHg or diastolic blood pressure $\geq$ 85 mmHg or antihypertensive medication use); (5) abnormal glucose homeostasis (fasting plasma glucose $\geq$ 100 mg/dL).

Statistical methods

Subjects were categorized based on tertiles of DASH dietary pattern scores. To compare general characteristics across tertiles, we used one-way ANOVA for continuous variables (including age, weight, BMI, waist circumference, and physical activity) and chi-square test for categorical variables (including current OCP and corticosteroid use, marital and menopausal status, and obesity). Dietary intakes (age and energy adjusted) were compared by using ANCOVA. To find the relation between DASH dietary pattern and risk of MetS, we used multivariate logistic regression in several models. First, we controlled for age (years) and energy intake (kcal/day). Additional adjustment was done for current oral contraceptive pill (OCP) use (yes or no), current corticosteroids use (yes or no), physical activity (MET-h/week), marital status (single/married), menopausal status (postmenopause/premenopause), and socioeconomic status (high/moderate/poor) in the second model II. Finally, further adjustment for BMI (kg/m^2) was done in the third model. To determine the association with features of the MetS, we constructed two models: age-adjusted and multivariable-adjusted model (additional adjustment for energy intake, physical activity, socioeconomic status, medication use, marital and menopausal status, as well as for mutual effects of other components of MetS including abdominal obesity, hypertriglyceridemia, low HDL-C, elevated blood pressure, and abnormal glucose homeostasis). For enlarged waist circumference, we did the analysis with and without energy intake in multivariable-adjusted model, since energy intake would be in the causal pathway. We also did the analysis based on both WC ≥88 cm and WC ≥80 cm. To calculate the trend of odds ratios across increasing categories of tertiles of DASH diet score, we considered the tertile categories as an ordinal variable in the models. All statistical analyses were done using SPSS (SPSS Inc, version 18). *P* values were considered significant at <0.05.

Results

General characteristics of study participants across tertiles of DASH diet score are presented in Table 1. Compared with participants in the lowest tertile, those in the highest tertile of DASH diet score were older. No significant differences were found in mean weight, waist circumference, and physical activity across tertiles of DASH diet score. Distribution of obese subjects was not significantly different across tertiles.

Table 1 Characteristics of study participants across tertiles of DASH diet score

	Tertiles of DASH diet score			P^a
	T1 (lowest) (n = 140)	T2 (n = 140)	T3 (highest) (n = 140)	
Age (years)	33.9 ± 7.5	35.2 ± 7.2	36.3 ± 6.7	0.02
Weight (kg)	61.5 ± 0.86	69.7 ± 6.98	63.7 ± 0.79	0.35
BMI (kg/m^2)	23.7 ± 0.32	23.9 ± 0.30	24.4 ± 0.31	0.26
Waist circumference (cm)	80.1 ± 0.87	81.1 ± 0.93	81.3 ± 0.89	0.57
Physical activity (Met-h/day)	88.3 ± 12.98	70 ± 9.14	77.4 ± 8.05	0.44
Current OCP use (%)	5	6	8.5	0.46
Current corticosteroid use (%)	3	0.7	0.7	0.21
Menopause (%)	6	7	4.5	0.59
Married (%)	69.5	75.5	75	0.47
Obesity[b] (%)	35	40.5	41.5	0.53

Data are mean ± standard error (except for age which is mean ± SD)

BMI body mass index, *OCP* oral contraceptive pills

[a] Obtained by the use of ANOVA and chi-square test, where appropriate

[b] BMI ≥30

Age- and energy-adjusted dietary intakes of study participants across tertile categories of DASH diet score are shown in Table 2. Those in the top tertile of DASH diet score had higher intakes of energy, carbohydrates, fruits, vegetables, nuts and legumes, and low-fat dairy compared with those in the bottom tertile. They also had higher intakes of fiber, folate, calcium, and magnesium than those in the lowest tertile. Dietary intakes of other macronutrients and food groups were not significantly different across tertiles of DASH diet score.

Multivariable-adjusted odds ratios for MetS across tertiles of DASH diet score are indicated in Table 3. After controlling for potential confounders, we found that individuals in the highest tertile of the DASH diet score had 81 % lower odds of MetS than those in the lowest category (OR 0.19; 95 % CI 0.07–0.96). Further, adjustment for BMI slightly weakened the association (OR 0.37; 95 % CI 0.14–0.91). When we performed the analysis based on WC ≥80 cm (as a component of MetS) instead of WC ≥88 cm, the association was strengthened.

Multivariable-adjusted odds ratios for features of MetS across tertiles of DASH diet score are provided in Table 4. After adjustment for potential confounders, we observed that individuals in the top tertile of DASH score had lower odds for enlarged waist circumference (for WC ≥ 88 cm: OR 0.46; 95 % CI 0.18–0.81, and for WC ≥ 80 cm: OR 0.32; 95 % CI 0.10–0.68), hypertriglyceridemia (OR 0.27; 95 % CI 0.10–0.86), low HDL-C levels (OR 0.22; 95 % CI 0.09–0.47), and high blood pressure (OR 0.20; 95 % CI 0.09–0.67). We found no significant association between adherence to the DASH diet and hyperglycemia either before or after adjustment for confounders.

Discussion

In this cross-sectional study, we found that women with greater adherence to the DASH diet were less likely to have the MetS and most of its features including enlarged waist circumference, hypertriglyceridemia, low HDL-C levels, and high blood pressure. This favorable association persisted in multivariate models accounting for several lifestyle-related variables. To the best of our knowledge, this is the first observational study that epidemiologically examined the association between DASH diet and MetS.

Despite the alarming prevalence of the MetS, there is still no definite specific diet for MetS. A growing body of

Table 2 Age- and energy-adjusted dietary intakes of study participants across tertiles of DASH diet score

	Tertiles of DASH diet score			P^a
	T1 (lowest) (n = 140)	T2 (n = 140)	T3 (highest) (n = 140)	
Nutrients				
Total energy intake (kcal)	2,546.5 ± 873.4	2,752.8 ± 914.8	3,021.3 ± 1,027.9	<0.001
Proteins (g/day)	127.2 ± 137.6	106.6 ± 83.1	126.9 ± 126.7	0.25
Fats (g/day)	105.9 ± 39.1	103.8 ± 36.0	113.0 ± 97.8	0.45
Carbohydrates (g/day)	279.1 ± 117.6	330.0 ± 130.2	385.5 ± 149.3	<0.001
Fiber (g/day)	15.5 ± 6.5	20.5 ± 8.1	28.9 ± 20.2	<0.001
Folate (μg/day)	240.1 ± 100.4	299.8 ± 105.7	400.0 ± 175.0	<0.001
Magnesium (mg/day)	2.3 ± 0.9	2.8 ± 0.9	3.5 ± 1.8	<0.001
Calcium (mg/day)	740.6 ± 324.5	929.8 ± 406.8	1,177.2 ± 455.2	<0.001
Food groups (g/day)				
Red meat	146.5 ± 98.1	138.7 ± 91.2	137.4 ± 117.2	0.72
Fruits	192.7 ± 168.1	359.4 ± 302.6	579.8 ± 350.8	<0.001
Vegetables	226.3 ± 114.9	310.8 ± 155.8	492.0 ± 309.8	<0.001
Legumes and nuts	50.7 ± 44.7	59.7 ± 40.6	70.6 ± 46.6	0.001
Low-fat dairy products	232.2 ± 216.6	370.5 ± 313.1	485.5 ± 300.4	<0.001
High-fat dairy products	56.6 ± 54.0	58.8 ± 49.5	73.2 ± 83.0	0.06
Refined grains	414.6 ± 230.6	398.1 ± 207.3	367.0 ± 241.7	0.20

Data are mean ± SD. Data for energy intake are adjusted for age. Data for other dietary variables are adjusted for age and total energy intake

[a] Obtained by the use of ANCOVA

evidence has shown that consumption of DASH diet might beneficially influence blood pressure and serum lipid profiles. Therefore, this healthy dietary pattern might be considered as a suitable diet for preventing MetS. In the current study, we found that adherence to the DASH diet in Iranian women was inversely associated with MetS. Our findings are in line with previous RCTs that have shown the favorable effects of the DASH diet on MetS [13, 14]. It must be kept in mind that the current study was the first observational investigation that assessed the relation between adherence to the DASH dietary pattern and MetS in the context of habitual intakes in free-living women. Data from observational studies are based on habitual dietary intakes of population and therefore are better reflection of real-world intakes and more generalizable to the whole population than those from RCTs, while in RCTs, habitual dietary intakes of population are neglected. Although there are no observational studies that directly assessed the association between adherence to the DASH diet and MetS, several documents have addressed the linkage between the DASH diet and hypertension, hyperlipidemia, visceral obesity [9, 24], and diabetes [16]. In the Nurses' Health Study, higher DASH scores were associated with 24 % reduced risk of CHD and 18 % lower risk of stroke [17]. Among youth with type 1 diabetes mellitus, greater adherence to the DASH diet was inversely associated with LDL/HDL ratio and HbA_{1C} concentrations [9, 25]. The same associations were also reported for low-density lipoprotein particle density, and BMI Z score in youth with type 2 diabetes mellitus [9]. In Health Professionals Follow-Up Study, a 1-SD increase in the DASH score was associated with 9–13 % reduced risk of type 2 diabetes [16]. In the current study, a nonsignificant relation between the DASH score and hyperglycemia might originate from the small sample of individuals (n = 27) with abnormal glucose homeostasis in our study population. In addition, the modified DASH score in a representative sample of Chinese adult population was associated with 27 % reduced risk of clustering of CVD risk factors [18]. Consistent with our findings, in a prospective study on 34,827 apparently healthy women, higher DASH diet scores were associated with significantly reduced risk of overall CVD and CHD [15]. In contrast to our findings, no associations were observed between DASH diet and venous thromboembolism (VTE) among these women [15]. In the prospective Iowa Women's Health Study (IWHS), greater adherence with the DASH diet was not associated with lower incidence of hypertension and mortality from coronary heart disease, stroke, or total cardiovascular disease [12]. These different findings might be explained by several reasons. The different association between the DASH diet and risk of CVD and VTE might be due to the different underlying disease pathways. Both blood pressure and lipid levels, which are favorably influenced by the DASH diet, have uncertain relationships with the risk of VTE [26]. In the IWHS, the DASH diet score was constructed based on food group recommendations for a fixed calorie level (2,000 kcal/day) rather than individualized daily calorie needs of participants. In addition, the narrow range of the score in this

Table 3 Multivariable-adjusted odds ratios (and 95 % CIs) for MetS across tertiles of DASH score

	Tertiles of DASH diet score			P^{e}_{trend}
	T1 (lowest) ($n = 140$)	T2 ($n = 140$)	T3 (highest) ($n = 140$)	
Metabolic syndrome[a] (based on WC ≥ 88 cm)				
Crude	1.00	0.64 (0.27–1.48)	0.50 (0.20–1.23)	0.12
Model 1[b]	1.00	0.63 (0.25–1.57)	0.43 (0.17–1.03)	0.05
Model 2[c]	1.00	0.10 (0.01–1.27)	0.19 (0.07–0.96)	0.03
Model 3[d]	1.00	0.31 (0.08–1.16)	0.37 (0.14–0.91)	0.01
Metabolic syndrome[2] (based on WC ≥ 80 cm)				
Crude	1.00	0.55 (0.21–1.22)	0.42 (0.18–1.11)	0.08
Model 1[b]	1.00	0.57 (0.18–1.19)	0.37 (0.11–0.95)	0.03
Model 2[c]	1.00	0.19 (0.01–1.20)	0.11 (0.05–0.80)	<0.001
Model 3[d]	1.00	0.27 (0.06–1.03)	0.22 (0.09–0.74)	<0.001

Values are odds ratio and 95 % CI

[a] Defined based on the presence of at least three of the following risk factors: (1) abdominal obesity (WC ≥88 cm or ≥80 cm as indicated); (2) hypertriglyceridemia (serum triglyceride levels ≥ 150 mg/dL); (3) low HDL-C (<50 mg/dL); (4) elevated blood pressure (systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥85 mmHg or antihypertensive medication use); (5) abnormal glucose homeostasis (fasting plasma glucose ≥ 100 mg/dL)

[b] Adjusted for age and energy intake

[c] Additionally adjusted for physical activity, socioeconomic status, medication use, and marital and menopausal status

[d] Further control for BMI

[e] Obtained by considering the tertile categories as an ordinal variable in the models

Table 4 Multivariable-adjusted odds ratios for features of MetS across tertiles of DASH score

	Tertiles of energy-adjusted DASH scores			P^{g}_{trend}
	T1 (lowest) ($n = 140$)	T2 ($n = 140$)	T3 (highest) ($n = 140$)	
Enlarged waist circumference[a] (based on WC ≥ 88 cm)				
Age-adjusted	1.00	0.59 (0.31–1.03)	0.33 (0.20–0.63)	0.01
Multivariable-adjusted (without energy)	1.00	0.68 (0.29–1.10)	0.39 (0.18–0.74)	0.01
Multivariable-adjusted[b]	1.00	0.71 (0.33–1.14)	0.46 (0.18–0.81)	0.02
Enlarged waist circumference[a] (based on WC ≥ 80 cm)				
Age-adjusted	1.00	0.41 (0.19–1.09)	0.25 (0.11–0.52)	0.001
Multivariable-adjusted (without energy)	1.00	0.49 (0.21–1.05)	0.21 (0.12–0.79)	0.001
Multivariable-adjusted[b]	1.00	0.58 (0.21–1.03)	0.32 (0.10–0.68)	0.001
Abnormal glucose homeostasis[c]				
Age-adjusted	1.00	0.83 (0.35–1.94)	0.65 (0.27–1.69)	0.13
Multivariable-adjusted[b]	1.00	0.91 (0.30–1.99)	0.71 (0.21–1.84)	0.38
Hyperglyceridemia[d]				
Age-adjusted	1.00	0.42 (0.18–1.02)	0.19 (0.06–0.59)	<0.001
Multivariable-adjusted[b]	1.00	0.50 (0.16–1.11)	0.27 (0.10–0.86)	0.01
Low HDL-c levels[e]				
Age-adjusted	1.00	0.18 (0.10–0.31)	0.14 (0.09–0.28)	<0.001
Multivariable-adjusted[b]	1.00	0.25 (0.09–0.57)	0.22 (0.09–0.47)	<0.001
High blood pressure[f]				
Age-adjusted	1.00	0.19 (0.11–0.31)	0.08 (0.06–0.20)	<0.001
Multivariable-adjusted[b]	1.00	0.31 (0.13–0.68)	0.20 (0.09–0.67)	<0.01

All values are odds ratio and 95 % CIs

[a] Waist circumference ≥88 cm or WC ≥80 as indicated

[b] Adjusted for age, energy intake, physical activity, socioeconomic status, medication use, marital and menopausal status, as well as other components of MetS

[c] Fasting plasma glucose ≥100 mg/dL

[d] Serum triglyceride ≥150 mg/dL

[e] Serum HDL-c levels <50 mg/dL

[f] Systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or antihypertensive medication use

[g] Obtained by considering the tertile categories as an ordinal variable in the models

population might contribute to the null associations reported. Moreover, the DASH score in this study unexpectedly did not correspond with sodium intake, indicating an unreliable DASH score.

The underlying mechanisms for the favorable relation between the DASH diet and MetS are not completely understood. High content of fruits, vegetables, whole grains, and low-fat dairy products of the DASH diet might provide some reasons. In addition, DASH diet is a rich source of fiber, potassium, magnesium, calcium, and phytochemicals [27]; all might contribute to the beneficial effects of the DASH diet on features of MetS [10, 13, 27, 28]. Furthermore, low red meat [29] and refined grain [28] content of DASH diet might also help explaining its favorable association with the MetS.

Strengths of the present study include a substantially large sample size and careful assessment of confounding. Some limitations should be taken into account while interpreting our findings. The major limitation is the cross-sectional design of the study which does not allow inferring causality. Large prospective cohort studies are required to provide an evidence for the causal relationship. As we used the FFQ for assessing dietary intakes, misclassification is another concern in our study, as is in any other epidemiologic study. Because of the nature of our study population, our findings may not be generalizable to males. The restriction to female nurses also limits generalizability. In addition, the FFQ could not provide precise measurement of sodium intake while it is a hallmark of the DASH diet. Also, we did not collect 24-hour urine sample in this population to assess sodium intake.

Using a different definition of MetS might affect our findings. Several clinical definitions have been proposed for MetS. In the present study, we used the updated and recommended definition by the Joint Scientific Statement. As the proposed waist circumference values for abdominal obesity in Iran have been resulted from small cross-sectional studies on nonrepresentative samples [30], we used international waist circumference cutoff points to define central obesity. Using a different cutoff point for waist circumference might slightly affect the associations.

In conclusion, our findings indicated an inverse association between adherence to the DASH eating plan and prevalence of MetS and most of its features among Iranian women. Further, prospective studies are required to confirm our findings.

Acknowledgments This study was supported by a joint grant from the Isfahan University of Medical Sciences and Lorestan University of Medical Sciences, Islamic Republic of Iran. The financial support for conception, design, data analysis, and manuscript drafting comes from Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran.

Conflict of interest None of the authors had any personal or financial conflict of interest.

References

1. Suzuki T, Hirata K, Elkind MS et al (2008) Metabolic syndrome, endothelial dysfunction, and risk of cardiovascular events: the Northern Manhattan Study (NOMAS). Am Heart J 156:405–410
2. Ford ES (2005) Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care 28:1769–1778
3. Ford ES, Li C, Zhao G (2010) Prevalence and correlates of metabolic syndrome based on a harmonious definition among adults in the US. J Diabetes 2:180–193
4. Fakhrzadeh H, Ebrahimpour P, Pourebrahim R, Heshmat R, Larijani B (2006) Metabolic syndrome and its associated risk factors in healthy adults: a population-based study in Iran. Metab Syndr Relat Disord 4:28–34
5. Esmaillzadeh A, Mirmiran P, Azadbakht L, Etemadi A, Azizi F (2006) High prevalence of the metabolic syndrome in Iranian adolescents. Obesity (Silver Spring) 14:377–382
6. Djousse L, Padilla H, Nelson TL, Gaziano JM, Mukamal KJ (2010) Diet and metabolic syndrome. Endocr Metab Immune Disord Drug Targets 10:124–137
7. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 13:3–9
8. Appel LJ, Moore TJ, Obarzanek E, DASH Collaborative Research Group et al (1997) A clinical trial of the effects of dietary patterns on blood pressure. N Engl J Med 336:1117–1124
9. Liese AD, Bortsov A, Gunther AL et al (2011) Association of DASH diet with cardiovascular risk factors in youth with diabetes mellitus: the SEARCH for Diabetes in Youth study. Circulation 123:1410–1417
10. Azadbakht L, Fard NR, Karimi M et al (2011) Effects of the Dietary Approaches to Stop Hypertension (DASH) eating plan on cardiovascular risks among type 2 diabetic patients: a randomized crossover clinical trial. Diabetes Care 34:55–57
11. Asemi Z, Tabassi Z, Samimi M, Fahiminejad T, Esmaillzadeh A (2013) Favourable effects of the Dietary Approaches to Stop Hypertension diet on glucose tolerance and lipid profiles in gestational diabetes: a randomised clinical trial. Br J Nutr 109:2024–2030
12. Folsom AR, Parker ED, Harnack LJ (2007) Degree of concordance with DASH diet guidelines and incidence of hypertension and fatal cardiovascular disease. Am J Hypertens 20:225–232
13. Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi T, Azizi F (2005) Beneficial effects of a Dietary Approaches to Stop Hypertension eating plan on features of the metabolic syndrome. Diabetes Care 28:2823–2831
14. Saneei P, Hashemipour M, Kelishadi R, Rajaei S, Esmaillzadeh A (2013) Effects of recommendations to follow the Dietary Approaches to Stop Hypertension (DASH) diet v. usual dietary advice on childhood metabolic syndrome: a randomised cross-over clinical trial. Br J Nutr 110:2250–2259
15. Fitzgerald KC, Chiuve SE, Buring JE, Ridker PM, Glynn RJ (2012) Comparison of associations of adherence to a Dietary Approaches to Stop Hypertension (DASH)-style diet with risks of cardiovascular disease and venous thromboembolism. J Thromb Haemost 10:189–198
16. de Koning L, Chiuve SE, Fung TT, Willett WC, Rimm EB, Hu FB (2011) Diet-quality scores and the risk of type 2 diabetes in men. Diabetes Care 34:1150–1156
17. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB (2008) Adherence to a DASH-style diet and risk of

coronary heart disease and stroke in women. Arch Intern Med 168:713–720
18. Gao B, Zhang L, Wang H (2013) Clustering of major cardiovascular risk factors and the association with unhealthy lifestyles in the Chinese adult population. PLoS ONE 8:e66780
19. Esmaillzadeh A, Azadbakht L (2008) Food intake patterns may explain the high prevalence of cardiovascular risk factors among Iranian women. J Nutr 138:1469–1475
20. Hassanzadeh A, Rajaie S, Esmaillzadeh A et al. (2014) A dish-based semi-quantitative food frequency questionnaire for assessment of dietary intakes in epidemiologic studies in Iran: design and development. Int J Prev Med 5:29–36
21. Adibi P, Esmaillzadeh A, Hassanzadeh A et al (2012) The study on the epidemiology of psychological, alimentary health and nutrition (SEPAHAN): overview of methodology. J Res Med Sci 17:S292–S298
22. United States Department of Health and Human Services NIoH, National Heart Lung, and Blood Institute. Your Guide to Lowering Your Blood Pressure With DASH. http://www.nhlbi.nih.gov/health/public/heart/hbp/dash/. Accessed 5 Dec 2006
23. Alberti KG, Eckel RH, Grundy SM et al (2009) Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 120:1640–1645
24. Nazare JA, Smith J, Borel AL et al (2013) Changes in both global diet quality and physical activity level synergistically reduce visceral adiposity in men with features of metabolic syndrome. J Nutr 143:1074–1083
25. Barnes TL, Crandell JL, Bell RA, Mayer-Davis EJ, Dabelea D, Liese AD (2013) Change in DASH diet score and cardiovascular risk factors in youth with type 1 and type 2 diabetes mellitus: the SEARCH for Diabetes in Youth Study. Nutr Diabetes 3:e91
26. Glynn RJ, Rosner B (2005) Comparison of risk factors for the competing risks of coronary heart disease, stroke, and venous thromboembolism. Am J Epidemiol 162:975–982
27. Most MM (2004) Estimated phytochemical content of the dietary approaches to stop hypertension (DASH) diet is higher than in the Control Study Diet. J Am Diet Assoc 104:1725–1727
28. Esmaillzadeh A, Azadbakht L (2006) Whole-grain intake, metabolic syndrome, and mortality in older adults. Am J Clin Nutr 83:1439–1440
29. Azadbakht L, Esmaillzadeh A (2009) Red meat intake is associated with metabolic syndrome and the plasma C-reactive protein concentration in women. J Nutr 139:335–339
30. Esmaillzadeh A, Mirmiran P, Azizi F (2005) Evaluation of waist circumference to predict cardiovascular risk factors in an overweight Tehranian population: findings from Tehran Lipid and Glucose Study. Int J Vitam Nutr Res 75:347–356