The Association between DASH Diet Adherence and Cardiovascular Risk Factors

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Abstract

Background: The dietary approaches to stop hypertension (DASH) encourages high fruit, vegetable, and lean protein consumption and low salt, red meat, and fat intake to prevent or treat hypertension. However, besides hypertension, adherence to this diet has been shown to decrease other cardiovascular risk factors. **Methods:** This study assessed the relationship between the DASH diet and cardiovascular risk factors in a cross-sectional study of 2,831 adults chosen by multistage cluster sampling from 27 counties of Khuzestan province, Iran. DASH scores were calculated using data obtained from a qualitative food frequency questionnaire. Regression models were used to evaluate the association of DASH scores and common cardiovascular risk factors. **Results:** Significant trends were observed across quintiles of DASH scores for systolic blood pressure, fasting blood sugar, triglyceride, total cholesterol, and its components ($p < 0{\cdot}05$). After adjusting for potential confounders such as sex, age, ethnicity, residence, wealth score, physical activity, energy intake, and family history of heart disease, the multiple regression analysis for each cardiovascular risk factor revealed that being in the highest quintile of total DASH score (OR = 0.72, 95% CI 0.52–0.99) was negatively associated with hyperglycemia. **Conclusions:** This study showed a positive relationship between DASH diet adherence and lower serum levels of glucose, triglycerides, and cholesterol. Prospective studies are needed to confirm these findings.

Keywords: *Cardiovascular diseases, diet therapy, hyperglycemia, hypertension, sodium*

Introduction

Cardiovascular diseases (CVDs) are the leading cause of global mortality, responsible for an estimated 17.8 million deaths in 2017, over 75% of which have occurred in low- and middle-income countries.[1] Dietary and lifestyle modifications are essential preventive strategies for CVD risk reduction.[2-4] Considering that meals entail a wide variety of foods with different mixtures of nutrients, which may have synergistic or antagonistic effects on each other, evaluating dietary patterns can provide valuable information to reducing the burden of chronic diseases beyond individual nutrients or food groups.[5,6]

The Dietary Approaches to Stop Hypertension (DASH) is a dietary pattern that recommends increased consumption of fruits, vegetables, whole grains, fish, nuts, dairy products, and vegetable oils, and reduced consumption of processed meats, simple sugars, desserts, alcohol, and fats.[7] Thus, the DASH dietary pattern promotes a higher intake of protective nutrients such as potassium, calcium, magnesium, fiber, and vegetable proteins with a lower intake of refined carbohydrates and saturated fats.[8] Several prospective studies[9,10] and meta-analysis[11,12] have found that following a DASH-style diet can be associated with a lower risk of CVD. According to a study performed among adults over 60, approximately 17% of all-cause and cardiovascular mortality was reduced by the DASH diet.[13] Protective effects of this diet on obesity,[14] metabolic syndrome,[15] diabetes,[12] and cancer[16] have also been previously reported.

There are limited data on the adherence to the DASH eating pattern among Iranian adults. The traditional diet of the Middle Eastern population particularly Iranian people includes large amounts of refined grains (high in hydrogenated fats) and a low intake of animal products, which is different from both western and eastern countries.[17-20] Hence, the objective of the present study was to investigate the

How to cite this article: Shoaibinobarian N, Danehchin L, Mozafarinia M, Hekmatdoost A, Eghtesad S, Masoudi S. The association between DASH diet adherence and cardiovascular risk factors. Int J Prev Med 2023;14:24.

Access this article online

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

DOI: 10.4103/ijpvm.ijpvm_336_21

Quick Response Code:

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association between adherence to the DASH dietary pattern and hypertension, hyperglycemia, dyslipidemia, metabolic syndrome and CVD risk in a population-based study in the Khuzestan province of Iran.

Methods

Study design and population

The data used in this cross-sectional study was obtained from the Khuzestan Comprehensive Health Study (KCHS). KCHS, a population-wide cross-sectional survey, was conducted from October 2016 to November 2019 among 30,500 Iranian adults in 27 counties of Khuzestan province, to assess the health state of adults in that region. In the initial phase of sampling, health houses within each district of Khuzestan province were chosen randomly (a total of 27 districts). Proportional to the population of each district, a total number of 1079 random Health Houses, including 299 and 780 health houses in the rural and urban areas, respectively were recruited. Subsequently, 30 individuals aged between 20 and 65 who qualified to eligibility criteria were randomly chosen from the people covered by each Health House. Details of the KCHS data/sample collection have been previously reported elsewhere.[21] Of the overall population, ten percent randomly selected for dietary assessment through a food frequency questionnaire (FFQ) and were included in our study. Participants with psychological, mental, or physical disorders at baseline, missing or incomplete information on the FFQ and/or the general lifestyle questionnaires (including questions on socio-economic status, history of diabetes, demographics, education, smoking, opium and alcohol use and anthropometric measurements) were excluded from this analysis. This study was approved by the ethics committee of the National Institute for Medical Research Development (IR.NIMAD.REC.1394.002).

Dietary assessment

Dietary intakes over the year before the study enrollment were assessed using a qualitative FFQ, consisting of 86 food items.[22] FFQs were completed by trained interviewers during a face-to-face interview. Data obtained for each food item on the FFQ was converted to grams per day using standard household measures,[23] after which energy and nutrient intakes were computed using the USDA food composition databases.[24]

Adherence to dash-style diet

The DASH score was calculated by focusing on eight components: dietary intakes of fruits, vegetables, nuts and legumes, low-fat dairy products and whole-grains, and low intake of salt, sweetened beverages, and red and processed meats.[25] To investigate individuals' adherence to the DASH diet, we first obtained energy-adjusted amounts of each component through the residual method.[26] Participants were then categorized into quintiles of energy-adjusted food and nutrient intakes. The highest scores were assigned to individuals in the highest quintile of grains, vegetables, fruits, low-fat dairy, legumes, and nuts. Distinctly, the lowest quintiles of intake in these food groups obtained the lowest scores. The reverse of this scoring method was also used for sodium, sweets, and red or processed meats. The scores of all eight components for each participant were then summed to construct the overall DASH score that ranged from 8 to 40.

Assessment of potential confounders

Trained personnel collected anthropometric data during the study enrollment using standardized methods and calibrated devices. Height was recorded without shoes to the nearest 0.1 centimeters on the Seca 206 roll-up measuring tape mounted on a wall, and body weight was measured to the nearest 0.1 kilograms with bare feet and light clothing using the Seca 762 mechanical scale. Waist circumference (WC) was also measured through a non-stretchable tape put at the mid-point between the last rib and upper part of the iliac crest to the nearest 0·1 cm. BMI was calculated as BMI = weight (in kilograms)/height (meters)^2. All measurements were carried out following National Institutes of Health guidelines.[27]

Other potential confounders assessed in this study included age, sex, ethnicity, residence, wealth score, physical activity, energy, heart disease family history degree1.

Physical activity was evaluated using the international physical activity questionnaire (IPAQ).[28] In this study, the level of physical activity was categorized into tertiles as low, medium, and high. Participants who engaged in 7 or more days of vigorous-intensity activity were categorized into high, and those engaged in 5 or more days of moderate-intensity activity and/or walking were considered medium.

Wealth scores as a surrogate of socioeconomic status were calculated using multiple correspondence analysis using the following variables: home area, having a bathroom inside the house (vs. outside in older Iranian buildings), taking trips abroad, and access to/ownership of a freezer, washing machine, dishwasher, laptop, internet, car (type), TV (type), vacuum cleaner and mobile. Individuals were categorized into quartiles based on the wealth scores calculated.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured twice in each arm, in the sitting position, and after at least 5 mi of rest, using analog Riester sphygmomanometers.

Biochemical assessment

Blood samples were collected from all participants after an 8-12 hour fast. Details of blood collection and testing were previously explained.[21] Serum levels of high-density lipoprotein-cholesterol (HDL-C), total cholesterol, fasting blood sugar (FBS), and triglycerides (TG) were measured by BT 1500 Auto Analyzer (Biotecnica Instruments, Italy), and low-density lipoprotein-cholesterol (LDL-C) was calculated using standard formulas.

Dyslipidemia was defined based on the American College of Cardiology/American Heart Association [ACC/AHA] Guideline on the Primary Prevention of Cardiovascular Disease, as well as the Iranian National Reports on dyslipidemia as the presence of one of the following criteria: TG level greater than 150 mg/dL, cholesterol level greater than 200 mg/dL and/or LDL-C level greater than 100 mg/dL, HDL-C lower than 40 mg/dL in men and 50 mg/dL in women, or anti-hyperlipidemia medication use.[29,30]

According to the American Diabetes Association, hyperglycemia was defined as FBS ≥100 mg/dL or a self-reported history of diabetes or glucose lowering medication use, compatible with past medical history.[31]

The American Heart Association definition was used to define hypertension as self-reported history of hypertension or antihypertensive drug use or SBP ≥130 and/or DBP ≥80 mmHg.[32]

In addition, the presence of metabolic syndrome was determined if three or more of the following five criteria were met: blood pressure over 130/85 mmHg, FBS over 100 mg/dL, TG level over 150 mg/dL, HDL-C less than 40 mg/dL (men) or 50 mg/dL (women) and waist circumference over 102 cm (men) or 88 cm (women).[33]

Prevalent CVD risk factors included heart diseases, ischemic heart disease, heart surgery history, heart attack, or heart stroke. Self-report was verified using components of the baseline examination for each cardiovascular condition.

Statistical analysis

The normal distribution of continuous variables was evaluated using the Kolmogorov–Smirnov test. All continuous variables were described as [mean ± standard deviation (SD)], and categorical variables were presented as definite frequencies (percentages) and were compared with a Fisher's exact test or Chi-square test if needed. The non-parametric Kruskal–Wallis test was applied to calculate the P value in Table 2. The final model was adjusted with established risk factors of CVD such as sex, age, ethnicity, residence, wealth score, physical activity, energy intake, and family history of heart disease in first degree relatives. DASH diet score was classified into five upward groupings on an ordinal scale. Prevalence or means of baseline characteristics were measured for each category. The relationship of the DASH diet index with CVD, metabolic syndrome, hyperglycemia, hypertension, and dyslipidemia, were examined using logistic regression. For each outcome of interest, two models were produced: (1) a model adjusted for age and sex (2) as model 1 but further adjusted for sex, age, ethnicity, residence, wealth score, physical activity, energy intake, and family history of heart disease in first degree relatives. The first quintile of the DASH score was regarded as the reference group for the multiple adjusted models. All statistical analyses were executed with the Statistical Package for the Social Sciences program (SPSS; version 26; 161 Chicago, IL, USA). Differences were considered to be statistically significant at $P < 0.05$.

Results

A total of 2,823 participants were included in the statistical analysis of this study, 1,021 (36.2%) of whom were male. Table 1 presents the demographic, behavioral, and health characteristics of participants categorized by DASH score quintiles. The means ± SD of age and BMI of participants was 40.6 ± 11.8 and 27.5 ± 5.3, respectively. Participants who adhered rigidly to the DASH diet tended to have moderate to high physical activity ($p = 0.007$). Additionally, they were less likely to have a history of diabetes ($p < 0.001$), hypertension ($p = 0.001$), and a family history of heart diseases. Most participants lived in urban areas [$n = 2,058$ (72.9%)]. Generally, no significant association was found between smoking, opium and alcohol use, or marital status and DASH score quintiles. The median DASH score (25–75 interquartile range) was 24 (21-27) in all participants.

The median of lipid and glycemic profiles, as well as blood pressure across the DASH score quintiles, are reported in Table 2. When we regarded DASH quintiles as a qualitative variable, a meaningful association was noticed between the score quintiles and SBP (Median: 112, 106-120), FBS (Median: 97.50, 89.10–108.60), TG (Median: 125.00, 83.00–184.20), HDL (Median: 49.50, 42.80–57.70), LDL (Median: 110.71, 88.66–133.34) and cholesterol (Median: 187.80, 161.20–215.40; $P < 0.05$).

Table 1: Sociodemographic, lifestyle and clinical parameter characteristics of the study population according to Total DASH Score in the Khuzestan Comprehensive Health Study (KCHS) (Mean values and standard deviations)

Variables	Total DASH Score						Total (*n*=2823)
	Q1 (*n*=565)	Q2 (*n*=565)	Q3 (*n*=564)	Q4 (*n*=565)	Q5 (*n*=564)	*P*	
Gender							
Male *n* (%)	230 (40.7%)	210 (37.2%)	183 (32.4%)	193 (34.2%)	205 (36.3%)	0.046*	1021 (36.2%)
Age							
Mean±SD	44.3±11.9	40.5±11.4	40.8±11.9	40.0±11.7	37.5±11.0	<0.001*	40.6±11.8
BMI							
Mean±SD	27.8±5.4	27.2±5.1	27.6±5.3	27.6±5.5	27.0±5.3	0.075	27.5±5.3
Energy							
Mean±SD	8366.7±2793.8	10159.9±2593.7	11857.5±2707.8	12867.8±2750.2	15586.0±3900.4	<0.001*	11766.2±3860.4
Marital							
Married *n* (%)	474 (83.9%)	461 (81.6%)	449 (79.6%)	456 (80.7%)	476 (84.4%)	0.167	2316 (82%)
Unmarried *n* (%)	91 (16.1%)	104 (18.4%)	115 (20.4%)	109 (19.3%)	88 (15.6%)		507 (18%)
Ethnicity							
Fars *n* (%)	92 (16.3%)	94 (16.7%)	118 (20.9%)	155 (27.5%)	84 (14.9%)	0.001*	543 (19.3%)
Arab *n* (%)	271 (48.1%)	277 (49.2%)	253 (44.9%)	258 (45.7%)	326 (57.9%)		1385 (49.2%)
Bakhtiari *n* (%)	152 (27%)	135 (24%)	135 (23.9%)	95 (16.8%)	106 (18.8%)		623 (22.1%)
Other *n* (%)	48 (8.5%)	57 (10.1%)	58 (10.3%)	56 (9.9%)	47 (8.3%)		266 (9.4%)
Residence							
Urban *n* (%)	417 (73.8%)	422 (74.7%)	433 (76.8%)	426 (75.4%)	360 (63.8%)	<0.001*	2058 (72.9%)
Rural *n* (%)	148 (26.2%)	143 (25.3%)	131 (23.2%)	139 (24.6%)	204 (36.2%)		765 (27.1%)
Wealth scores							
Q1 *n* (%)	177 (31.5%)	134 (23.9%)	146 (25.9%)	135 (23.9%)	120 (21.5%)	<0.001*	712 (25.3%)
Q2 *n* (%)	152 (27%)	116 (20.7%)	141 (25%)	121 (21.4%)	144 (25.8%)		674 (24%)
Q3 *n* (%)	138 (24.6%)	182 (32.5%)	150 (26.6%)	144 (25.5%)	173 (30.9%)		787 (28%)
Q4 *n* (%)	95 (16.9%)	128 (22.9%)	126 (22.4%)	165 (29.2%)	122 (21.8%)		636 (22.6%)
Diabetes History *n* (%)	73 (12.9%)	25 (4.4%)	37 (6.6%)	32 (5.7%)	23 (4.1%)	<0.001*	190 (6.7%)
BP History *n* (%)	78 (13.8%)	57 (10.1%)	56 (9.9%)	44 (7.8%)	40 (7.1%)	0.001*	275 (9.8%)
Heart disease family history d1 *n* (%)	108 (19.1%)	120 (21.2%)	139 (24.6%)	151 (26.7%)	151 (26.8%)	0.006*	669 (23.7%)
Physical activity							
Low *n* (%)	201 (35.9%)	157 (27.8%)	166 (29.5%)	190 (33.6%)	181 (32.1%)	0.007*	895 (31.8%)
Moderate *n* (%)	212 (37.9%)	242 (42.8%)	267 (47.4%)	251 (44.4%)	239 (42.4%)		1211 (43%)
High *n* (%)	147 (26.3%)	166 (29.4%)	130 (23.1%)	124 (21.9%)	144 (25.5%)		711 (25.2%)
Smoking Status							
Never *n* (%)	492 (87.1%)	506 (89.6%)	519 (92%)	518 (91.7%)	508 (90.1%)	0.103	2543 (90.1%)
Current *n* (%)	54 (9.6%)	37 (6.5%)	34 (6%)	31 (5.5%)	41 (7.3%)		197 (7%)
Former *n* (%)	19 (3.4%)	22 (3.9%)	11 (2%)	16 (2.8%)	15 (2.7%)		83 (2.9%)
Opium Use status							
Never *n* (%)	551 (97.5%)	552 (97.7%)	556 (98.6%)	556 (98.4%)	548 (97.2%)	0.563	2763 (97.9%)
Current *n* (%)	10 (1.8%)	6 (1.1%)	4 (0.7%)	6 (1.1%)	8 (1.4%)		34 (1.2%)
Former *n* (%)	4 (0.7%)	7 (1.2%)	4 (0.7%)	3 (0.5%)	8 (1.4%)		26 (0.9%)
Alcohol Use Status							
Never *n* (%)	560 (99.1%)	557 (98.6%)	552 (97.9%)	555 (98.2%)	548 (97.2%)	0.350	2772 (98.2%)
Current *n* (%)	2 (0.4%)	4 (0.7%)	6 (1.1%)	3 (0.5%)	5 (0.9%)		20 (0.7%)
Former *n* (%)	3 (0.5%)	4 (0.7%)	6 (1.1%)	7 (1.2%)	11 (2%)		31 (1.1%)

Results from the logistic regression models fit to describe the association between CVD and its risk factors with quintiles of DASH score as categorical variables are shown in Table 3. In the multivariate model (after adjustment for potential confounders), the odds of hyperglycemia were significantly lower in the highest quintile of total DASH score [OR = 0.72, 95% CI (0.52–0.99)]. Hypertension, dyslipidemia, and metabolic syndrome were not statistically significant with DASH quintiles in the multivariate model.

Table 2: Distribution of metabolic and biochemical parameters among the total DASH score quintiles

	Total Dash score																		
	Q1			Q2			Q3			Q4			Q5			*P*	Total		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3		Median	Q1	Q3
SBP (mm Hg)	112	108	122	112	108	120	110	108	120	110	101	120	112	105	120	0.017*	112	106	120
DBP (mm Hg)	74	68	80	72	68	80	72	68	80	70	62	80	72	64	80	0.050	72	68	80
FBS (mg/dL)	100.00	91.30	112.80	97.40	89.90	108.05	96.70	88.40	108.30	96.85	88.25	107.15	96.70	89.00	106.50	<0.001*	97.50	89.10	108.60
TG (mg/dL)	138.80	93.00	193.40	123.75	83.20	190.20	126.20	82.30	184.10	117.10	75.40	173.00	117.90	78.90	184.80	0.001*	125.00	83.00	184.20
Cholesterol (mg/dL)	189.60	160.50	218.60	188.20	159.40	216.20	189.80	166.50	218.00	187.90	162.10	215.20	183.60	157.00	212.60	0.034*	187.80	161.20	215.40
HDL (mg/dL)	48.70	42.00	56.70	49.10	42.30	57.20	50.50	43.90	59.10	49.60	43.00	57.70	49.20	42.70	57.70	0.034*	49.50	42.80	57.70
LDL (mg/dL)	113.33	89.18	134.97	110.29	89.44	133.40	113.04	91.20	136.22	110.50	88.88	133.10	106.44	84.04	127.42	0.017*	110.71	88.66	133.34

Abbreviations: DASH=Dietary Approaches to Stop Hypertension, DBP=diastolic blood pressure, SBP=systolic blood pressure, FBS= fasting blood sugar, TG=triacylglycerides, HDL=high-density lipoprotein, LDL=low-density lipoprotein

Discussion

The present study was performed on Iranian adults residing in Khuzestan province, and the relationship between adherence to the DASH dietary pattern and cardiovascular risk factors was assessed. To our knowledge, this is the first cross-sectional study estimating the association between adherence to DASH-style diet and CVD risk factors in the adult population of southern Iran, with its specific dietary habits, containing large portion sizes and high consumption of refined grains (bread and white rice). We did not find a remarkable association between DASH score and CVD and its known-related metabolic parameters, for instance, blood pressure and measures of lipids metabolism. Our findings complied with previous studies;[34,35] however, we also observed that being in the highest quintile of DASH score had a significant inverse relationship with serum glucose levels.

The results of previous studies on the association between DASH scores and dyslipidemia are controversial; a previous study conducted on 88,517 female nurses aged 34 to 59 years without a history of diabetes or CVD in 1980 indicated no relationship between DASH scores and serum lipid levels.[25] On the other hand, Obarzanek *et al.*[36] reported that following the DASH diet reduced HDL cholesterol, LDL cholesterol, and total cholesterol and had no substantial impacts on triglycerides.

Our findings of higher DASH scores being inversely associated with hyperglycemia were in accordance with previous studies.[12] For example, a study conducted by Azadbakht *et al.*[37] among 31 individuals with type 2 diabetes, following 8 weeks of DASH-style diet, demonstrated that DASH dietary patterns had favorable outcomes on CVD related risk factors and glycemic control. Likewise, a randomized clinical trial included 34 women diagnosed with gestational diabetes mellitus, showing that adherence to DASH dietary pattern for 4 weeks improved glucose tolerance compared with the control diet.[38] This favorable finding might be due to the higher consumption of fiber and whole grains. Moreover, a significant amount of low–glycemic index foods such as dairy, vegetables, and whole grains, as well as a low-energy diet, impact the regulation of blood glucose levels.[39] Other investigators had also previously reported adherence to the DASH-style diet being associated with lower FBS levels.[40] Barnes *et al.*[41] found that a favorable modification in DASH scores improved HbA1c levels among youth with type 1 diabetes.

Although numerous studies found the protective effects of the DASH diet on blood pressure,[15,42-45] we did not find any significant association in this regard. Alterations might explain this finding in participants' diet after a diagnosis of hypertension.

The most prominent strength of this the study is its relatively large multi-ethnic population-based sample

Table 3: Adjusted odds ratios and 95% confidence intervals for the association between studied variables and Total DASH Score among KCHS Participants

	Total DASH Score					
	Q1 (*n*=565)	Q2 (*n*=565)	Q3 (*n*=564)	Q4 (*n*=565)	Q5 (*n*=564)	*P*
CVD *n*=141 (4.98%)						
Partial adjusted*	1 (ref)	0.48 (0.27-0.85)	0.59 (0.35-1.00)	0.79 (0.48-1.30)	0.69 (0.39-1.21)	
Full adjusted$	1 (ref)	0.49 (0.27-0.89)	0.55 (0.31-0.98)	0.75 (0.42-1.35)	0.60 (0.29-1.22)	0.308
Hyperglycemia *n*=1251 (44.20%)						
Partial adjusted	1 (ref)	0.85 (0.66-1.08)	0.72 (0.56-0.92)	0.75 (0.59-0.96)	0.77 (0.60-0.99)	
Full adjusted	1 (ref)	0.86 (0.66-1.11)	0.70 (0.53-0.91)	0.70 (0.53-0.93)	0.72 (0.52-0.99)	0.020
Hypertension *n*=661 (23.36%)						
Partial adjusted	1 (ref)	0.72 (0.53-0.96)	0.81 (0.60-1.09)	0.88 (0.66-1.18)	1.04 (0.77-1.40)	
Full adjusted	1 (ref)	0.78 (0.57-1.06)	0.86 (0.62-1.18)	0.94 (0.67-1.31)	1.10 (0.75-1.61)	0.460
Dyslipidemia *n*=2376 (83.96%)						
Partial adjusted	1 (ref)	0.87 (0.62-1.23)	0.93 (0.66-1.32)	0.80 (0.57-1.13)	0.84 (0.59-1.17)	
Full adjusted	1 (ref)	0.84 (0.58-1.19)	0.85 (0.58-1.23)	0.72 (0.49-1.05)	0.75 (0.49-1.16)	0.150
Metabolic syndrome *n*=850 (30.04%)						
Partial adjusted	1 (ref)	0.93 (0.71-1.21)	0.81 (0.62-1.06)	0.83 (0.63-1.08)	0.95 (0.72-1.24)	
Full adjusted	1 (ref)	0.98 (0.75-1.29)	0.84 (0.63-1.12)	0.87 (0.64-1.18)	1.05 (0.74-1.48)	0.884

*Adjusted for Sex and Age. $Adjusted for Sex, Age, Ethnicity, Residence, Wealth score, Physical Activity, Energy, Heart disease family history degree

size and high participation rate from various regions of Khuzestan province. The dominant limitation of this study was the higher female participation in comparison to males. However, this limitation was overcome during data analysis by reporting gender-adjusted estimates. Also, the study design was cross-sectional, so we could not assess causality. Moreover, FFQ's are generally known to overestimate food intakes; to overcome this problem, we excluded individuals who were under-/over-reporting their energy intakes.

Conclusions

In summary, this survey showed a positive relationship between DASH diet adherence and lower serum levels of glucose, TG, and cholesterol. Prospective studies are recommended to confirm these findings.

Acknowledgment

We want to thank the participating universities and faculties for their cooperation, our study sites for their appreciable efforts, and the people of Khuzestan for their kind participation in this study.

Financial support and sponsorship

This project was funded by the National Institute for Medical Research Development (NIMAD, Grant number: 940406) and Abadan University of Medical Sciences (Grant number: 96U-319).

Conflicts of interest

There are no conflicts of interest.

Received: 26 Jul 22 **Accepted:** 27 Oct 22
Published: 25 Feb 23

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