



Adherence to Dietary Approaches to Stop Hypertension Eating Plan and Prevalence of Irritable Bowel Syndrome in Adults

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Background/Aims

Despite huge evidence on the link between adherence to dietary approaches to stop hypertension (DASH) eating pattern and several metabolic abnormalities, the association of this diet with irritable bowel syndrome (IBS) has not been investigated so far. We aim to examine the association between adherence to the DASH diet and prevalence of IBS symptoms and subtypes in adults.

Methods

This cross-sectional study was done among 3362 adult people in Isfahan, Iran. Usual dietary intakes were assessed using a validated 106-item dish-based semi-quantitative food frequency questionnaire. To investigate participants' adherence to DASH-style diet, we created DASH score based on 8 main foods and nutrients emphasized or minimized in the DASH diet. Participants were classified into 3 categories according to their DASH-style diet scores. A validated modified Persian version of the Rome III questionnaire was applied for assessment of IBS.

Results

Totally, 22.2% of study participants were affected by IBS. After adjustment for potential confounding factors, we found that participants in the highest tertile of DASH score had lower odds of IBS (OR, 0.65; 95% CI, 0.50-0.83) compared with those in the lowest tertile. The same findings were also reached for IBS with constipation (OR for the highest vs the lowest tertile of DASH-style diet = 0.56; 95% CI, 0.38-0.85). No significant association was seen between adherence to DASH-style diet and IBS with diarrhea (OR, 1.31; 95% CI, 0.83-2.06).

Conclusions

We found a significant inverse association between adherence to DASH dietary pattern and odds of IBS and IBS with constipation. Further prospective studies are required to confirm these findings.

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Key Words

Adult; Dietary approaches to stop hypertension; Iran; Irritable bowel syndrome

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Introduction

Irritable bowel syndrome (IBS) is a highly prevalent functional gastrointestinal (GI) disorder, characterized by abdominal discomfort or pain along with altered bowel habit.¹ The pathophysiology is complex and not well understood. Some potential factors such as disorder of the brain-gut axis, visceral hypersensitivity, disturbances in GI motility and secretion and psychosocial factors can explain its pathophysiology.² The prevalence of this disorder varies across countries and depends on the diagnostic criteria used.³ The result of a recent meta-analysis demonstrated that the pooled global prevalence of IBS was 11.2%.⁴ This disorder may impose substantial health care costs and reduce the quality of life in these patients.⁵⁻⁸

Lifestyle factors including diet has been demonstrated to influence IBS symptoms.^{9,10} Diets low in fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs) may relieve the symptoms.^{11,12} Low adherence to Mediterranean diet was also associated with stimulated functional GI symptoms.¹³ Adherence to healthy dietary patterns was associated with a reduced risk of IBS.¹⁴ There is evidence indicating the involvement of low-grade inflammation within the gut wall in the pathophysiology of IBS.^{15,16} Therefore, dietary patterns with anti-inflammatory features may help control symptoms of this condition. Dietary approaches to stop hypertension (DASH) eating plan, a dietary pattern that is char-

acterized by high intakes of vegetables, fruits, whole grains, fish, poultry, and nuts along with restricted intakes of red meat, saturated fat, refined grains and sweetened beverages,¹⁷ has been shown to cool down inflammation.¹⁸ Originally suggested for high blood pressure,¹⁹ the DASH diet has been shown to beneficially influence other inflammatory conditions including obesity,²⁰ cardiovascular disease,²¹ diabetes,²² and metabolic syndrome.²³ Emerging evidence supports the hypothesis that DASH diet may prevent or ameliorate IBS symptoms by its positive effects on body inflammation. To our knowledge, there is no previous investigation on the association of adherence to DASH diet and IBS. Therefore, this study aims to examine the association between adherence to the DASH diet and prevalence of IBS symptoms and subtypes in adults.

Materials and Methods

Study Population

This cross-sectional study was performed within the framework of the Study on the Epidemiology of Psychological, Alimentary Health and Nutrition (SEPAHAN) project which was done to evaluate the epidemiological aspects of functional gastrointestinal disorders (FGIDs) and their association with lifestyle and psychological measures. Detailed information regarding the study design, participants' recruitment, and study implementation have been

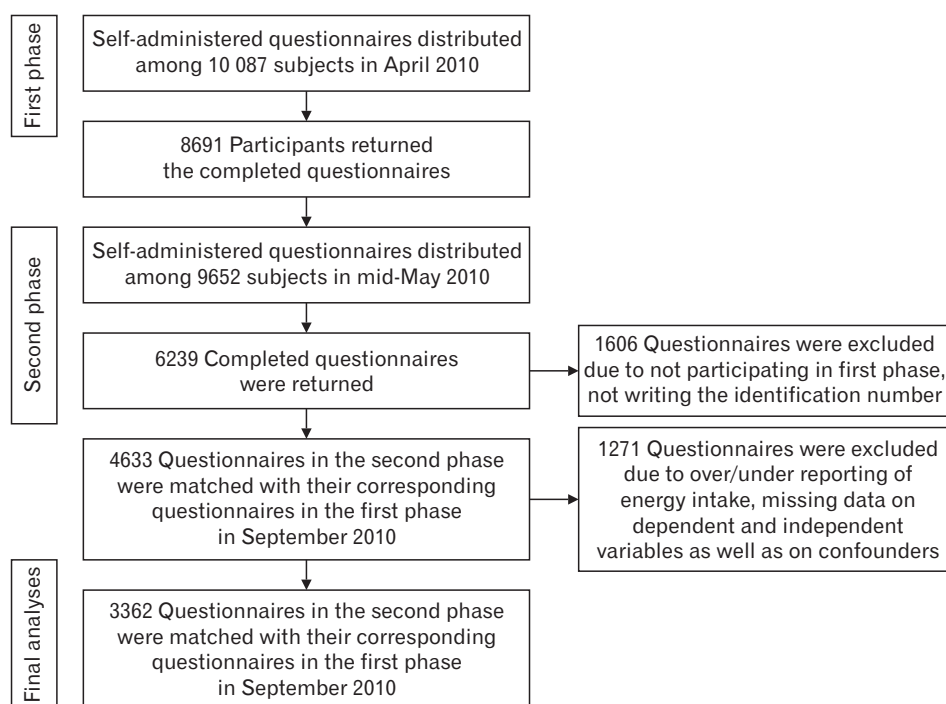


Figure. Flowchart of study selection process (adapted from Ebrahimpour-Koujan et al³⁸).

reported elsewhere.²⁴ Totally, we did our sampling in employees of 50 university-affiliated health centers in the Isfahan province. The study was conducted in 2 separate phases during April 2010 to May 2010. In the first phase of SEPAHAN, 10 087 self-administered questionnaires on demographic information, medical history, anthropometric measures, lifestyle, and dietary factors were distributed among invited subjects and 8691 questionnaires were answered and returned (response rate: 86.16%). At the second phase, another set of questionnaires on GI health information was sent out to the same persons and 6239 returned the completed questionnaires (response rate: 64.64%). After merging data from both phases, we had information on 4633 subjects, who provided complete information on diet and functional gastrointestinal disorders. In the present analysis, we excluded individuals with total daily calorie intake outside the range of 800-4200 kcal, as under- and over-reporters of energy intake. Furthermore, subjects with missing data on any relevant variables were excluded. Finally, 3362 participants were investigated in this study. The flowchart of study selection process is provided in Figure. Prior to the initiation of the study, a written informed consent form was taken from each participant. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki. This study was approved by the Bioethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran (Approval No. 189069, 189082, and 189086).

Dietary Assessment

Self-administered, Willett-format, dish-based, 106-item semi-quantitative food frequency questionnaire (FFQ) (DS-FFQ), was used to obtain dietary data. The questionnaire was designed and validated for use in Iranian adults.²⁵ Details on design, foods included, and the validity of this questionnaire has been reported elsewhere. Briefly, we provided a comprehensive list of foods and dishes commonly consumed by this population. Then, those foods that were nutrient-rich, often consumed or contributed to between-person variation were selected. Eventually, this process led to remaining of the 106 food items in 5 various categories in the questionnaire: (1) mixed dishes (cooked or canned, 29 items); (2) grains (different types of bread, biscuits, cakes and potato, 10 items); (3) dairy products (dairy, butter and cream, 9 items); (4) fruits and vegetables (22 items); and (5) miscellaneous food items and beverages (including fast foods, nuts, sweets, desserts and beverages, 36 items). In order to provide precise and accurate estimates, the portion size of foods and mixed dishes as a unit with the same perception were given to all people. Nine multiple choice frequency response categories ranging from “never or < 1/month” to “≥ 12/day” were provided for

reporting dietary intakes of participants. The number of response categories for the food list varied from 6 to 9 choices. For foods consumed infrequently, we omitted the high-frequency categories, while the number of multiple choice categories increased for common foods with a high intake. Finally, daily intake of all food items was computed and then converted to grams per day using household measures.

Adherence to Dietary Approaches to Stop Hypertension-style Diet

Participants' adherence to DASH-style diet was assessed by DASH scores based on 8 components emphasized or minimized in the DASH diet, including high intake of fruits, vegetables, nuts and legumes, dairy products, and low intake of grains, red and processed meats, sugar-sweetened beverages (SSB) and sweets, and sodium. In this study, we used the total dairy consumption instead of low-fat dairy intake, due to lack of data on the type and amount of fat in dairy products in our DS-FFQ. In addition, we considered both refined and whole grains as a single group of grains in the current study because consumption of whole-grain foods in Iran is very low (< 10 g/day). High amounts of refined grains (such as white bread and rice) are consumed by Iranian adults.²⁶ In the original DASH diet scoring method, a high score has been assigned to whole-grain intake.²⁷ Due to above mentioned reasons, we modified the original DASH diet scoring method by considering all grains as a non-healthy food. Then, each participant was classified into deciles in terms of consumption of these components. We assigned a maximum score of 10 to those in the top decile of fruits, vegetables, dairy products, nuts, and legumes intake, and a score of 1 to individuals in the bottom decile. Regarding food items, for which low intake is recommended in nutritional guidelines, (red and processed meat, total grains, SSB and sweets, and sodium), reverse scoring was applied. That is a maximum score of 10 assigned to individuals with the lowest consumption, and a score of 1 to participants with the greatest consumption. Eventually, to derive total DASH score, we summed up the scores of 8 components each participant has received. Therefore, total DASH score in the study population was at the range of 8 and 80.

Assessment of Irritable Bowel Syndrome

Symptom-based diagnostic criteria for IBS were identified by a modified Persian version of the Rome III questionnaire.²⁴ Since the descriptors used in the original version of Rome III questionnaire (never, < 1 day/month, 1 day/month, 2-3 days/month, 1 day/week, > 1 day/week, and every day) were difficult to be discriminated

by most participants during the validation of the questionnaire, we modified the descriptors to only 4 item rating scale (ie, never or rarely, sometimes, often, and always).²⁴ Participants were also asked about the presence of each symptom in the past 3 months. According to the Rome III criteria, IBS is a condition characterized by recurrent abdominal pain or discomfort at least sometimes in the previous 3 months along with 2 or more of the following criteria: improvement with defecation, pain with a change in stool frequency, and pain with a change in form (appearance) of stool. IBS with constipation was defined as having IBS and both of the following criteria: (1) hard or lumpy stools at least sometimes and (2) lack of loose, mushy or watery stools. IBS with diarrhea was defined as having IBS and both of the following criteria: (1) lack of hard or lumpy stools and (2) loose, mushy or watery stools at least sometimes.

Assessment of Other Variables

Required information on other variables including age, sex, weight, height, smoking habits (non-smokers, ex-smokers, and current smokers), diabetes, and colitis was obtained from self-administered questionnaires. To assess physical activity of participants, General Practice Physical Activity Questionnaire was applied. In the current analysis, subjects with activity of ≥ 1 hour/week were considered as physically active. Participants were questioned regarding diet-related practices including chewing sufficiency, meal regularity, intra-meal fluid consumption, as well as the frequency of breakfast consumption and fried food intake. Dental status was also evaluated and individuals were classified as “fully dentate,” “lost 1-5 teeth,” and “lost > 5 teeth.”

Statistical Methods

In the present study, we categorized participants based on

Table 1. Characteristics of Study Participants in Subjects With and Without Irritable Bowel Syndrome and Also in Tertile Categories of Dietary Approaches to Stop Hypertension Diet Score

Variables	IBS		P-value ^a	Tertiles of DASH dietary pattern score			P-value ^a
	Yes (n = 748)	No (n = 2614)		T1 (n = 1190)	T2 (n = 1050)	T3 (n = 1122)	
Age (yr)	36.04 ± 7.51	36.37 ± 7.96	0.340	35.78 ± 7.77	36.34 ± 7.90	36.78 ± 7.91	0.010
BMI (kg/m ²)	24.91 ± 3.90	24.90 ± 3.80	0.940	24.62 ± 3.76	24.86 ± 3.92	25.24 ± 3.76	0.001
Female	65.1	56.3	< 0.001	49.2	58.8	67.4	< 0.001
Education (university graduated)	61.9	61.9	1.000	60.7	63.2	61.9	0.450
Current smokers	15.1	13.4	0.240	14.1	14.0	13.3	0.820
Physically active ^b	12.4	13.4	0.490	13.9	13.5	12.1	0.420
Chronic diseases ^c	4.8	2.4	0.001	2.3	3.0	3.7	0.140
Regular meal pattern							
Never/sometimes	42.2	39.0	0.100	41.3	40.4	37.4	0.130
Often/always	57.8	61.0		58.7	59.6	62.6	
Chewing sufficiency							
A lot	10.3	13.8	0.010	11.8	12.9	14.3	0.200
Fluid consumption							
≥ 3 glasses/day	3.3	3.2	0.950	4.1	3.1	2.4	0.070
Breakfast skipping ^d	8.6	7.0	0.130	8.1	6.8	7.1	0.460
Frequent fried food intake							
≤ 3 times/wk	83.9	84.7	0.590	79.4	84	90.8	< 0.001
> 3 times/wk	16.1	15.3		20.6	16.0	9.2	
Tooth loss							
Lost > 5 tooth	8.2	7.7	0.600	8.0	8.4	7.0	0.440

^aANOVA for continuous variables and chi-squared test for categorical variables.

^b ≥ 1 hour/week physical activity.

^cChronic disease included: diabetes and colitis.

^dDefined as individuals who were eating breakfast < 5 times/week.

IBS, irritable bowel syndrome; DASH, dietary approaches to stop hypertension; BMI, body mass index. Values are presented as mean \pm SD or %.

tertiles of DASH-style diet scores. General characteristics of study subjects across tertiles of DASH score were compared by one-way ANOVA for continuous variables and chi-square test for categorical variables. We also used ANCOVA to compare dietary intakes as well as mean scores of DASH diet components (age, sex, and energy adjusted) across tertiles of DASH score. Multivariable logistic regression in several adjusted models was used to investigate the association between DASH-style diet and IBS and its subtypes. In the first model, we controlled for age (year), sex (male/female), and energy intake (kcal/day). Additional adjustments were done for marital status (married/single/divorced/widow), smoking (yes/no), physical activity (less/more than 1 hour per week), presence of chronic diseases (yes/no), supplement use (yes/no), and medication use (yes/no). Finally, further adjustments were done for other confounding factors of diet-related behaviors including regularity of meals consumption (never/sometimes/often/always), speed of eating (< 10 minutes/ \geq 10 minutes), adequacy of chewing (a lot/moderately/little), skipping breakfast (never or 1 day per week/2-4 days per week/5-6 days per week/everyday), drinking fluids while eating meals (one glass or less/2-3 glasses/3-4 glasses/> 4 glasses), consumption of fried foods (never/1-3 times per week/4-6 times per week/everyday), and status of denture (have all teeth/lost 1-5 teeth/lost > 5 teeth) were done in the last model. In all these analyses, the

first tertile of DASH score was considered as reference. In addition, stratified analysis by gender was also done. To assess the trend of odds ratios (ORs) across increasing tertiles of DASH-style diet, we considered the tertile categories as ordinal variable. All statistical analyses were done using Statistical Package for Social Sciences (version 19.0; IBM Corp, Armonk, NY, USA). *P*-values were considered significant at < 0.05.

Results

Totally, 22.2% of study participants (18.6% men and 24.9% women) were affected by IBS. The average energy intake of study participants was 2379 ± 826 kcal. Percentage of energy derived from carbohydrates, proteins and fats was 49.0%, 14.0%, and 37.0%, respectively. General characteristics of study participants separately by IBS and non-IBS participants and also across tertiles of DASH scores are presented in Table 1. Participants with IBS were more likely to be female (65.1% vs 56.3%, $P < 0.001$), have chronic diseases (4.8% vs 2.4%, $P = 0.001$) and less likely to have sufficient chewing (10.3% vs 13.8%, $P = 0.010$) than those without IBS. Subjects in the top tertile of DASH score were slightly older, had higher mean body mass index and were more likely to be female, and less likely to consume fried foods than those in the bot-

Table 2. Dietary Intakes of Study Participants by Tertile Categories of Dietary Approaches to Stop Hypertension Diet Score

Variables	Tertiles of DASH dietary pattern score			<i>P</i> -value ^a
	T1 (n = 1190)	T2 (n = 1050)	T3 (n = 1122)	
Food groups				
Fruits	176.64 \pm 6.32	316.43 \pm 6.43	464.70 \pm 6.42	< 0.001
Vegetables	177.36 \pm 3.39	236.23 \pm 3.45	306.00 \pm 3.44	< 0.001
Nuts, legumes, and soy	48.66 \pm 1.13	57.89 \pm 1.15	65.49 \pm 1.15	< 0.001
Dairy products	201.11 \pm 7.43	345.70 \pm 7.56	504.04 \pm 7.55	< 0.001
Grains	517.41 \pm 4.52	428.83 \pm 4.60	357.03 \pm 4.59	< 0.001
Sugar-sweetened beverages and sweets	66.49 \pm 1.50	51.29 \pm 1.52	38.48 \pm 1.52	< 0.001
Red and processed meats	94.94 \pm 1.40	84.22 \pm 1.42	73.56 \pm 1.42	< 0.001
Nutrients				
Sodium	4495.89 \pm 26.69	4329.98 \pm 27.15	4189.11 \pm 27.10	< 0.001
Energy (kcal/day)	2701.23 \pm 24.13	2375.13 \pm 25.25	2060.72 \pm 24.51	< 0.001
Carbohydrate (g/day)	294.76 \pm 1.53	290.97 \pm 1.56	296.17 \pm 1.55	0.04
Protein (g/day)	85.91 \pm 0.43	88.06 \pm 0.44	90.86 \pm 0.44	< 0.001
Fat (g/day)	97.61 \pm 0.58	100.10 \pm 0.59	98.20 \pm 0.59	0.008
Fiber (g/day)	20.09 \pm 0.17	22.54 \pm 0.17	25.29 \pm 0.17	< 0.001
Calcium (mg/day)	849.91 \pm 13.00	955.11 \pm 13.22	1138.20 \pm 13.20	< 0.001
Folate (μ g/day)	589.62 \pm 3.85	569.30 \pm 3.92	566.69 \pm 3.91	< 0.001

^aANCOVA for all variables.

DASH, dietary approaches to stop hypertension.

Values are presented as mean \pm SE. Energy intake is adjusted for age and sex, all other values are adjusted for age, sex, and energy intake.

tom tertile.

Age-, sex- and energy-adjusted intakes of nutrients and food groups across tertiles of DASH scores are presented in Table 2. Participants in the highest tertile of DASH score had higher intakes of fruits, vegetables, nuts, legumes and soy, and dairy products; and lower intakes of grains, SSB and sweets, red and processed meats compared with those in the lowest quartile. Significant differences were also found in dietary intakes of sodium, energy, carbohydrate, protein, fat, fiber, calcium, and folate across tertiles of DASH scores.

Age-, sex- and energy-adjusted scores of DASH diet components across tertiles of DASH scores are provided in Table 3. Greater adherence to DASH diet was associated with higher scores of fruits, vegetables, nuts, legumes and soy, dairy products, grains, SSB and sweets, red and processed meats, and sodium ($P < 0.001$).

Multivariable-adjusted ORs for IBS and its subtypes across tertile categories of DASH-style diet are shown in Table 4. After controlling for potential confounders, participants in the highest tertile of DASH score had lower odds of IBS (OR, 0.65; 95% CI, 0.50-0.83) compared with those in the lowest tertile. The same findings were also reached for IBS with constipation (IBS-C) (OR, 0.56; 95% CI, 0.38-0.85). No significant associations were found between adherence to the DASH diet and odds of IBS with diarrhea (OR, 1.31; 95% CI, 0.83-2.06).

Stratified analyses by gender (Table 5) revealed an inverse association between adherence to DASH-style diet and odds of IBS in women (OR, 0.66; 95% CI, 0.49-0.89; $P_{\text{trend}} = 0.006$). Although such association was not seen in men, it was near significance level (OR, 0.69; 95% CI, 0.44-1.07; $P_{\text{trend}} = 0.05$).

Discussion

In this cross-sectional study in a large sample of Iranian adults, we found that participants in the top tertile of DASH score had lower odds of IBS compared with those in the bottom tertile. This association remained significant even after adjustment for a wide range of confounding variables. The same findings were also reached for IBS-C. After stratified analysis by gender, the associations remained significant only in women. To our knowledge, this is among the first population-based studies that examined the association between adherence to the DASH eating pattern and IBS.

In the current study, we found that adherence to the DASH diet was significantly associated with lower odds of IBS in the adult population. We also found a significant inverse association between adherence to the DASH diet and odds of IBS-C. We are aware of no previous study that has examined the association of DASH diet and IBS. However, DASH diet is a healthy eating pattern. In a study in France, consumption of healthy dietary pattern was not associated with IBS.²⁸ It should be noted that the healthy dietary pattern in the above-mentioned study was characterized by high intakes of whole grains and low intake of milk, while in the DASH diet we scored in our study, total grain and milk intake was considered as non-healthy and healthy food items, respectively. Recently, diets low in FODMAPs may help in decreasing the risk and alleviating IBS symptoms.^{29,30} Given that DASH-style diet is a source of healthy foods such as fruits, vegetables and whole grains, which all contain large amounts of FODMAPs,³¹ one may therefore expect that DASH diets can actually worsen symptoms in IBS. However, it must be noted that in the present study, we did not separate

Table 3. Mean Scores for Dietary Approaches to Stop Hypertension Diet Components by Tertile Categories of Dietary Approaches to Stop Hypertension Diet Score

DASH diet components	Tertiles of DASH dietary pattern score			P-value ^a
	T1 (n = 1190)	T2 (n = 1050)	T3 (n = 1122)	
Fruits	3.69 ± 0.07	5.60 ± 0.07	7.38 ± 0.07	< 0.001
Vegetables	4.09 ± 0.07	5.46 ± 0.07	7.09 ± 0.07	< 0.001
Nuts, legumes and soy	4.77 ± 0.07	5.49 ± 0.08	6.18 ± 0.08	< 0.001
Dairy products	3.85 ± 0.07	5.59 ± 0.07	7.22 ± 0.07	< 0.001
Grains	4.39 ± 0.05	5.37 ± 0.05	6.64 ± 0.05	< 0.001
Sugar-sweetened beverages and sweets	4.61 ± 0.08	5.45 ± 0.08	6.56 ± 0.08	< 0.001
Red and processed meats	4.92 ± 0.07	5.47 ± 0.07	6.17 ± 0.07	< 0.001
Sodium	5.19 ± 0.04	5.50 ± 0.04	5.80 ± 0.04	< 0.001

DASH, dietary approaches to stop hypertension.

Values are presented as mean ± SE. All values are adjusted for age, sex, and energy intake.

^aANCOVA for all variables.

Table 4. Multivariable-adjusted Odds Ratios (95% Confidence Intervals) for Irritable Bowel Syndrome and Its Subtypes Across Tertile Categories of Dietary Approaches to Stop Hypertension Diet Score

Variables	Tertiles of DASH dietary pattern score			P trend
	T1 (n = 1190)	T2 (n = 1050)	T3 (n = 1122)	
IBS				
Crude	1.00	0.98 (0.80-1.19)	0.75 (0.61-0.91)	0.006
Model 1 ^a	1.00	0.92 (0.74-1.14)	0.65 (0.52-0.82)	< 0.001
Model 2 ^b	1.00	0.87 (0.70-1.08)	0.63 (0.50-0.80)	< 0.001
Model 3 ^c	1.00	0.86 (0.68-1.08)	0.65 (0.50-0.83)	0.001
IBS-C				
Crude	1.00	1.30 (0.96-1.75)	0.71 (0.51-0.99)	0.070
Model 1	1.00	1.25 (0.90-1.73)	0.62 (0.42-0.90)	0.010
Model 2	1.00	1.18 (0.85-1.65)	0.59 (0.40-0.86)	0.009
Model 3	1.00	1.11 (0.78-1.57)	0.56 (0.38-0.85)	0.008
IBS-D				
Crude	1.00	0.73 (0.48-1.11)	1.10 (0.76-1.59)	0.610
Model 1	1.00	0.70 (0.44-1.11)	1.13 (0.74-1.74)	0.540
Model 2	1.00	0.71 (0.45-1.13)	1.14 (0.74-1.75)	0.520
Model 3	1.00	0.75 (0.46-1.21)	1.31 (0.83-2.06)	0.240

DASH, dietary approaches to stop hypertension; IBS, irritable bowel syndrome; IBS-C, IBS with constipation; IBS-D, IBS with diarrhea.

^aModel 1: adjusted for age, sex, and energy intake.

^bModel 2: further adjusted for marriage status, smoking, chronic diseases, physical activity, supplement use, and medication use.

^cModel 3: further adjusted for regular meal pattern, eating rate, chewing sufficiency, breakfast skipping, fluid consumption, fried food intake, and dental status.

fruits and vegetables with different contents of FODMAPs in our DASH diet scoring. On the other hand, unlike actual DASH diets that contains high amounts of whole grain foods, we categorized total grain as non-healthy food items due to high amounts of refined grains intake in Iranian diet. It is important to note that cereals are one of the most important sources of FODMAPs and therefore, low intake of cereals in the highest tertile of DASH score can be a possible explanation for this finding. It must also be kept in mind that low content of fat in DASH diets may be responsible for the beneficial protective association of DASH and IBS.^{9,32} Given the involvement of inflammation in the pathogenesis of IBS symptoms,³³ the beneficial effect of DASH-style diets may also be attributed to its influence on cooling down inflammation.¹⁸ The DASH diet is a low glycemic index dietary pattern, which is naturally rich in fruits, vegetables, whole grains, legumes, low-fat dairy products, mono/polyunsaturated fats, fiber, antioxidants and minerals including magnesium, calcium, and potassium.¹⁷ Findings of a meta-analysis demonstrated that long-term adopting of a low glycemic

Table 5. Multivariable-adjusted Odds Ratios (95% Confidence Intervals) for Irritable Bowel Syndrome Across Tertile Categories of Dietary Approaches to Stop Hypertension Diet Score, Stratified by Gender

Variables	Tertiles of DASH dietary pattern score			P trend
	T1	T2	T3	
IBS				
Men (n)				
Crude	604	433	366	
Crude	1.00	0.74 (0.54-1.02)	0.65 (0.46-0.92)	0.010
Model 1 ^a	1.00	0.67 (0.47-0.96)	0.65 (0.43-0.96)	0.020
Model 2 ^b	1.00	0.61 (0.42-0.89)	0.61 (0.40-0.92)	0.010
Model 3 ^c	1.00	0.59 (0.39-0.88)	0.69 (0.44-1.07)	0.050
Women (n)				
Crude	586	617	756	
Crude	1.00	1.10 (0.85-1.42)	0.74 (0.58-0.96)	0.010
Model 1	1.00	1.10 (0.84-1.44)	0.69 (0.52-0.91)	0.006
Model 2	1.00	1.06 (0.81-1.40)	0.68 (0.51-0.90)	0.005
Model 3	1.00	1.05 (0.78-1.40)	0.66 (0.49-0.89)	0.006

^aModel 1: adjusted for age and energy intake.

^bModel 2: further adjusted for marriage status, smoking, chronic diseases, physical activity, supplement use, and medication use.

^cModel 3: further adjusted for regular meal pattern, eating rate, chewing sufficiency, breakfast skipping, fluid consumption, fried food intake, and dental status.

DASH, dietary approaches to stop hypertension; IBS, irritable bowel syndrome.

index diet can favorably affect the pro-inflammatory markers such as C-reactive protein.³⁴ Furthermore, fruits and vegetables have also been reported to have anti-inflammatory properties due to their high contents of fiber and antioxidants.³⁵ Regarding dairy products, the results of previous meta-analyses have indicated that consumption of dairy products may possess protective effects against inflammation.³⁶ Moreover, findings from a recent meta-analysis revealed that dietary magnesium intake was inversely associated with serum C-reactive protein concentrations.³⁷ Totally, the anti-inflammatory effects of these foods and nutrients can explain the beneficial effects of DASH diets on IBS. In terms of IBS-C, high fiber content of DASH diets can explain the protective associations.

The strengths of our study include the assessment of a large sample size and being the first report on the association between adherence to the DASH diet and odds of IBS, as well as taking a wide range of potential confounders into account. Several limitations need to be considered. First, the cross-sectional design of the study does not allow us to infer the causal relationship between DASH diets and IBS. Therefore, further studies, in particular with a prospective design, are warranted to confirm these findings. Second, we used questionnaire-based data for identification of IBS in the current study. Although the Rome III questionnaire has been

validated in Iranian adults, the possibility of misclassification cannot be completely eliminated. Third, although a validated FFQ was used to measure dietary intake, some degree of measurement error and misclassification is inevitable. Finally, our study participants were general adults working in 50 different health centers across the Isfahan province; thus, generalization of our results to the general Iranian population should be made with caution.

In conclusion, we found a significant inverse association between adherence to DASH dietary patterns and odds of IBS and IBS-C. Further prospective studies are required to confirm these findings.

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