Public Health Nutrition: 24(18), 6085–6093 doi:10.1017/S1368980021003608

Adherence to the dietary approaches to stop hypertension dietary pattern and rheumatoid arthritis in Iranian adults

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Submitted 3 March 2021: Final revision received 10 August 2021: Accepted 17 August 2021: First published online 20 August 2021

Abstract

Objective: To examine the hypothesis that rheumatoid arthritis (RA) patients are less likely than healthy individuals to adhere to the dietary approaches to stop hypertension (DASH) dietary pattern.
Design: A multi-centre cross-sectional study involving a total of 300 eligible Iranian adults (aged >19 years; 93·0 % female) recruited during 2019–2020. Participants' actual dietary intakes were measured via self-administered 3-d dietary records. The DASH score was computed based on the energy-adjusted intakes of eight major dietary components usually emphasised (i.e. fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains) or minimised (i.e. sweets, red or processed meats and sodium) in the DASH diet. The higher the DASH score of subjects, the greater their adherence to the DASH pattern.
Setting: The outpatient clinics of major general hospitals in Shiraz, Iran.
Participants: 100 incident cases with definite RA according to the 2010 American College of Rheumatology/European League Against Rheumatism Classification Criteria for RA and 200 apparently healthy controls frequency-matched by gender and age.
Results: After adjusting for several potential covariates in the binary logistic regression analysis, RA cases were less likely than controls to have high adherence to the DASH pattern (OR = 0·08; 95 % CI 0·03, 0·20; $P = 0·001$).
Conclusions: Our findings in a sample of Iranian adults revealed that RA patients are less likely than healthy individuals to adhere to the DASH dietary pattern. However, the potential causal association of greater adherence to the DASH pattern and lower risk of RA needs to be confirmed by prospective studies of high methodological quality.

Keywords
Diet
Rheumatoid arthritis
Iran
Adult
Cross-sectional Studies

Key Points

- This is the first study to examine the potential association of adherence to the DASH dietary pattern and RA.
- RA patients were less likely than healthy individuals to adhere to the DASH pattern.
- Findings might implicate the potential application of DASH pattern in non-pharmacological prevention strategies for RA.

Rheumatoid arthritis (RA) is an autoimmune-mediated systemic inflammatory disease in which joint inflammation and destruction is recognised as the central hallmark[1–3]. It is 2–3 times more prevalent in women than in men and, despite occurring at any age, its peak incidence is in the sixth decade of life[1–4]. With a global prevalence of 0·5–1·0 %, RA represents a major public health concern and contributes to substantial mortality, morbidity and healthcare costs as well as a significant loss in quality of life[1–4]. It is also the most common form of inflammatory arthritis in Iran, affecting 0·2–1·0 % of Iranian adults[5]. Due to the increasing prevalence of this chronic, progressive and debilitating disease and the difficult nature of its pharmacological treatment, developing novel, effective and non-pharmacological prevention strategies is of utmost priority[1–4,6,7].

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Risk of RA is influenced by a host of genetic and environmental determinants which possibly interact with each other in complex yet not fully understood networks[2,6,7]. Dietary factors are among the environmental determinants of RA risk to gain considerable interest in the literature in recent years, mainly because they are potentially amenable to modification[8–12]. Nevertheless, the existing evidence on the potential association of diet and risk of RA is still fairly controversial and inconclusive[2,6,8,11,13]. This could be largely attributed to the fact that most research in this respect have traditionally focussed on the intakes of individual dietary elements (e.g. nutrients or food groups)[8,11]. Even though studying individual dietary elements could help us understand the underlying biological mechanisms of a given disease, their effects might be too small to detect and could be confounded by the effects of overall dietary patterns[14–16]. To overcome the inherent limitations of this traditional approach, the dietary pattern analysis has been widely promoted as an alternative method for comprehensive assessment of diet–disease relationships[14–16]. In brief, dietary patterns are defined either *a-posteriori* by applying multivariable statistical methods (e.g. principal component analysis, cluster analysis and reduced rank regression) on available dietary intakes data, or *a-priori* by evaluating the overall diet quality via determining subjects' level of adherence to the dietary indices or food consumption models (e.g. the alternative healthy eating index-2010 (AHEI-2010), the Mediterranean dietary pattern and the dietary approaches to stop hypertension (DASH) dietary pattern)[14–16]. In contrast to the traditional approach, the holistic approach of dietary pattern analysis is more easily translated into clinical and public health strategies and also appropriately takes into account the complexity of potential antagonistic and synergistic interactions among individual dietary elements in the food matrix[14–16]. In addition, it captures a broader and more realistic picture of food consumption and provides a unique opportunity to better clarify the potential role of nutrition in the pathogenesis of chronic diseases with complex aetiologies such as RA[8,9,14–16].

Among dietary patterns defined by the *a-priori* approaches to dietary pattern analysis, the DASH dietary pattern is one of the most well-studied patterns that not only has greater adherence to which been associated with a lower risk of hypertension, but also with a reduction in the risk of all-cause mortality and other chronic health outcomes (e.g. CVD, cancer, type-2 diabetes and neurodegenerative disease)[17–20]. Although we are unaware of any previous studies on the potential relationship between adherence to the DASH pattern and RA, promising evidence from randomised controlled trials (RCT) regarding the beneficial effects of DASH diet on a number of conditions involved in RA pathogenesis (e.g. oxidative stress, inflammation, obesity and gut microbiota dysbiosis)[21–25] makes it reasonable to assume that higher adherence to this pattern might reduce the RA risk. The present work was therefore aimed to examine the potential association of adherence to the DASH dietary pattern and RA in a sample of Iranian adults, hypothesising that RA patients are less likely than healthy individuals to adhere to this pattern.

Materials and Methods

Study population and sampling

The completed STROBE Statement checklist of items that should be included in reports of cross-sectional studies is available as Online Source 1. The present multi-centre cross-sectional study was conducted on 100 RA cases and 200 controls frequency-matched by gender and 10 years age intervals. These 300 subjects (aged >19 years; 93·0 % female) were recruited via convenience sampling method from eligible Iranian adults admitted to the outpatient clinics of major general hospitals (i.e. Hafez and Namazi) in Shiraz (i.e. the 4th most populated city in Iran with an estimated population of 1 651 114 in 2020) between 22 May 2019 and 21 May 2020. RA cases were outpatients admitted to the rheumatology clinics (i.e. the referral centres in Shiraz for those suffering from rheumatic diseases) with <6 months from symptom onset who were newly classified as having 'definite RA' based on the 2010 American College of Rheumatology/European League Against Rheumatism Classification Criteria for RA[26]. In this widely validated criteria set, classification as 'definite RA' is based on the confirmed presence of synovitis in ≥1 joint, absence of an alternative diagnosis better explaining the synovitis and achieving a total score of ≥6 out of 10 from the individual scores in the following four domains: number and site of involved joints (range 0–5), serological abnormality (range 0–3), elevated acute-phase response (range 0–1) and symptom duration (range 0–1)[26]. It is notable that in the absence of a true gold standard for RA diagnosis, the 2010 American College of Rheumatology/European League Against Rheumatism Classification Criteria for RA provides the best estimates from the current approaches used and has been reported to detect RA cases among various target populations with a sensitivity of 82·0 %[26,27]. To avoid detection bias, RA classification was performed by an experienced and independent rheumatologist blinded to the study hypothesis. Controls were apparently healthy individuals without RA (i.e. no joints with definite clinical synovitis and no self-reported signs or symptoms of synovitis such as pain, swelling, or tenderness)[26] admitted for annual health check-ups.

The participant flow throughout the study is illustrated in Fig. 1. In order to obtain the required sample size, a total of 369 potentially eligible subjects (128 RA cases and 241 controls) were invited to participate in this study. Of these, 118 RA cases and 230 controls agreed to do so and were consecutively enrolled to be examined for eligibility (i.e. the overall, case and control participation rates were

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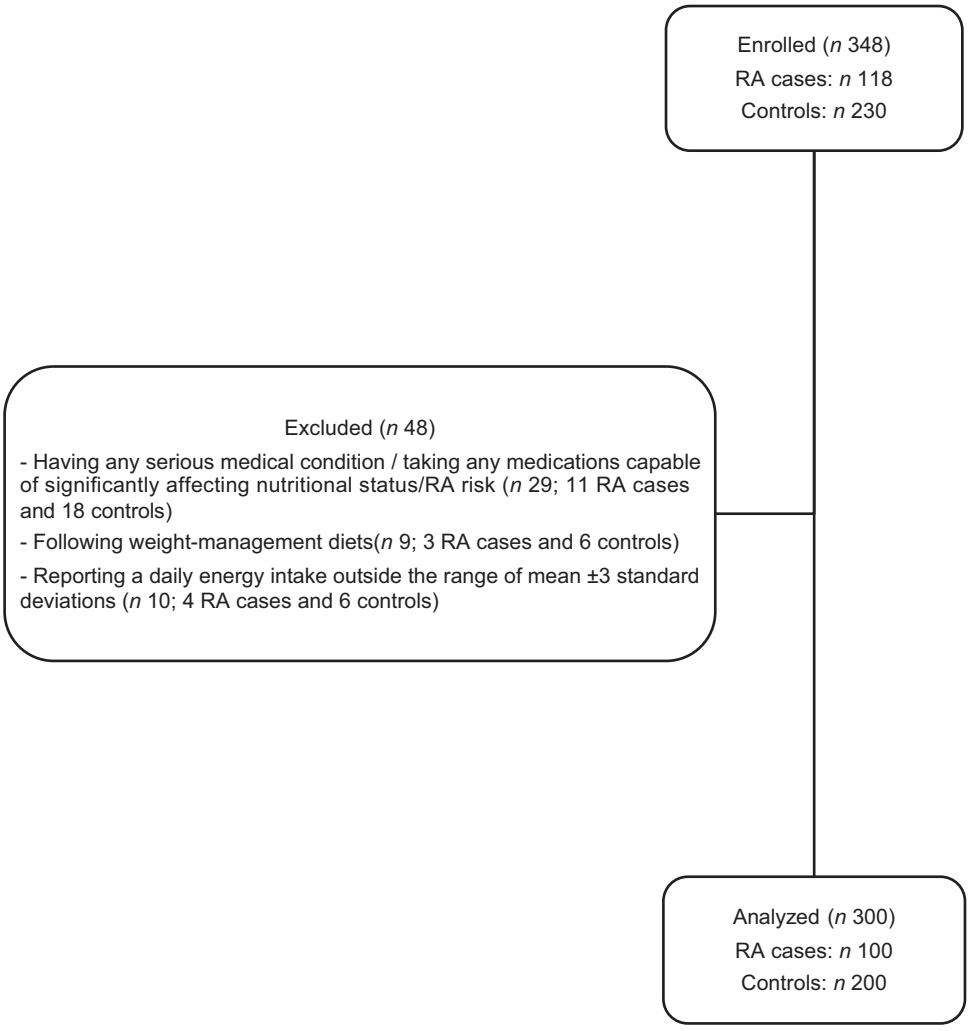

Fig. 1 Participant flow throughout the study. RA, rheumatoid arthritis

94·3, 92·2 and 95·4 %, respectively). After excluding those with any serious medical conditions (e.g. diagnosed cancer or major psychiatric, neurologic, respiratory, gastrointestinal, hepatic, renal, cardiovascular, endocrine and metabolic disorders; pregnancy, breastfeeding or menopause) or taking any medications capable of significantly affecting nutritional status/RA risk (*n* 29), those following weight-management diets (*n* 9), and those with a reported daily energy intake outside the range of mean ± 3 SDs (*n* 10), 100 RA cases and 200 controls were confirmed eligible to be included in the study and were analysed.

Measurements

Dietary intakes

To eliminate the possibility of recall bias, participants' actual dietary intakes were measured via self-administered 3-d dietary records completed for 2 weekdays and 1 weekend day. In order to obtain more accurate data, subjects were initially trained how to complete the dietary records by an experienced and independent dietitian. The same dietitian then analysed the provided dietary records. To do so, the mean daily grams of intake for any food items mentioned in the dietary records were first calculated using the Iranian Manual for Household Measures, Cooking Yields Factors and Edible Portion of Foods[28] and then entered into the Nutritionist IV (First Databank Inc., San Bruno, CA, USA) to estimate the daily energy and nutrient intakes for each participant. It is noteworthy that the Nutritionist IV databases included the United States Department of Agriculture food composition database plus a database for Iranian food items based on the Food Composition Table of Iran[29]. All dietary intakes were energy-adjusted according to the residual method described by Willett and Stampfer[30] and then presented as daily intake/1000 kcal.

From four main methods to construct a composite score representing the adherence to the DASH dietary pattern, we chose the one proposed by Fung et al.[31] as it is

https://doi.org/10.1017/S1368980021003608 Published online by Cambridge University Press

believed to better capture the actual characteristics of this pattern[32] and also because it is the only method that considers the intake of sweets (i.e. a food group which its consumption has been positively associated with risk of RA)[8,10,11]. According to this method[31], the DASH score is computed based on the energy-adjusted intakes of eight major dietary components usually emphasised (i.e. fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains) or minimised (i.e. sweets, red or processed meats and sodium) in the DASH diet[17,19]. To do so, subjects were initially classified according to the energy-adjusted quintile (Q) categories of their intakes of these components[31]. For fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains, the scores of 1, 2, 3, 4 and 5 were then assigned to those in the Q1 (lowest), Q2, Q3, Q4 and Q5 (highest), respectively[31]. On the other hand, the exact opposite of this scoring protocol was used for sweets, red or processed meats and sodium[31]. The scores of all eight components were then summed up together to derive an overall DASH score theoretically ranging from 8 to 40 for every participant[31]. The higher the overall DASH score of subjects, the greater their adherence to the DASH dietary pattern[31].

Other variables

Data on gender (male, female), age (years), education (≤12 years, >12 years), family income per capita (Million Rial/month), family history of RA (yes, no), supplement intake (yes, no), smoking (yes, no) and alcohol intake (yes, no) were gathered by general questionnaires through face-to-face interviews.

Anthropometric characteristics were recorded with participants standing in an upright position and wearing minimal clothing and no shoes. Weight and height were measured to the nearest 0·1 kg and 0·001 m using a SECA 881 digital floor scale and a SECA 214 portable stadiometer (SECA Inc., Hamburg, Germany), respectively. BMI was then calculated based on the following standard formula: BMI (kg/m^2) = weight (kg)/[height (m)]^2. Waist circumference was also recorded to the nearest 0·001 m by an ergonomic circumference measuring tape (SECA 201, SECA Inc., Hamburg, Germany) at the narrowest point between the lowest rib and the iliac crest while subjects were at the end of a normal expiration.

Physical activity was assessed during face-to-face interviews by the valid and reliable Persian version of International Physical Activity Questionnaire short form[33] and expressed as metabolic equivalent-min/d. This questionnaire is a self-administered 7-item open-access instrument developed for assessment of physical activity among adults aged 15–69 years with proven validity and reliability in more than 12 countries[34,35]. The International Physical Activity Questionnaire short form generates a summary score as metabolic equivalent-min/d by asking the respondents about three specific types of activity (i.e. walking, moderate-intensity activity and vigorous-intensity activity) undertaken within the last week in any of the four following domains: (a) leisure time; (b) domestic and gardening; (c) work-related and (d) transport-related physical activity[35].

Participants' enrolment and eligibility examination, face-to-face interviews and anthropometric measurements were all done by an experienced independent dietician blinded to the study hypothesis in order to avoid interviewer bias.

Statistical analysis

The required sample size for this study was calculated as 84–92 RA cases and 167–183 controls using the OpenEpi 3·01[36] and considering the followings: two-sided confidence level = 95·0 %; statistical power = 80·0 %; ratio of controls to cases = 2; least extreme OR to be detected = 0·45 (extracted from a study on the association of adherence to the Mediterranean dietary pattern and risk of RA)[37]; proportion of controls with exposure = 44·6 % (i.e. the reported proportion of Iranian adults with high adherence to the DASH dietary pattern)[38]; and an estimated proportion of cases with exposure = 26·6 %. However, we decided to recruit 100 RA cases and 200 controls to increase the precision of the study.

Subjects were classified into three tertile categories (n 100 in each tertile) based on the DASH score, with tertiles 1, 2 and 3 representing low, medium and high adherence to the DASH dietary pattern, respectively. The χ^2 or Fisher's exact tests were used for comparison of categorical variables between RA cases and controls or among tertiles of DASH score, as appropriate. The normality assumption for continuous variables was first examined using the Shapiro–Wilk test and those with non-normal distributions were normalised by standard transformation methods before any further analysis. The independent samples t-test and the one-way ANOVA were then used for comparison of continuous variables between RA cases and controls and among tertiles of DASH score, respectively. In case of any significant differences among tertiles of DASH score, the one-way ANOVA was also followed by pairwise between-group comparisons using the Bonferroni post-hoc test in order to adjust for multiple comparisons. The crude and multivariable-adjusted ORs and 95 % CI for RA by tertiles of DASH score were computed using the binary logistic regression analysis. The multivariable-adjusted model 1 was adjusted for gender, education, family history of RA, supplement intake, smoking and alcohol intake as potential covariates. The multivariable-adjusted model 2 was adjusted for covariates in Model 1 as well as for age, family income per capita, BMI, waist circumference, physical activity and energy intake. To assess the overall trend of OR across increasing tertiles of DASH score, the categorised DASH score was used as a continuous predictor in the binary logistic regression analysis. The IBM SPSS

https://doi.org/10.1017/S1368980021003608 Published online by Cambridge University Press

Statistics 21 (IBM Corp., Armonk, NY, USA) was used for statistical analysis, considering a two-sided *P*-value of <0·050 as significant.

Results

The characteristics of RA cases and controls are presented in Table 1. The nutrient intakes of RA cases and controls are also shown in Online Source 2. The DASH score ranged from 8 to 39 among study participants. RA cases were less likely to have >12 years of education and had lower family income per capita and higher BMI, waist circumference and energy intake than controls (all $P < 0·050$). They also had lower DASH score and intakes of fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains as well as higher intakes of sweets and red or processed meats (all $P < 0·050$). No other significant differences were observed between RA cases and controls.

The characteristics of study participants by tertiles of DASH score are shown in Table 2. The nutrient intakes of study participants by tertiles of DASH score are also presented in Online Source 3. Significant differences were observed in education, BMI, supplement intake, alcohol intake, intakes of all DASH components and RA among tertiles of DASH score (all $P < 0·050$). Compared to those with low adherence, participants with high adherence to the DASH dietary pattern were less likely to have RA and more likely to have alcohol intake and >12 years of education (all $P < 0·050$). They also had higher intakes of fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains as well as lower intakes of sweets, red or processed meats and sodium (all $P < 0·001$).

The crude and multivariate-adjusted ORs and 95 % CI for RA by tertiles of DASH score are presented in Table 3. After adjusting for several potential covariates in the binary logistic regression analysis (i.e. the multivariable-adjusted model 2), RA cases were less likely than controls to have high adherence to the DASH pattern (OR = 0·08; 95 % CI 0·03, 0·20; $P = 0·001$).

Discussion

To our knowledge, this is the first study on the potential association of adherence to the DASH dietary pattern and RA. Overall, findings of this study in a sample of Iranian adults confirm our hypothesis that RA patients are less likely than healthy individuals to adhere to the DASH pattern. If confirmed in prospective studies of high methodological rigour, our findings might implicate the potential application of DASH pattern in

Table 1 Characteristics of RA cases and controls[a,b]

	All (*n* 300)		RA (*n* 100)		Control (*n* 200)		
Characteristics	n	%	n	%	n	%	*P*
DASH score	24·0	6·8	20·5	5·9	25·8	6·5	<0·001
Gender							>0·999
Male	21	7·0	7	7·0	14	7·0	
Female	279	93·0	93	93·0	186	93·0	
Age (years)	47·8	9·4	48·2	9·8	47·5	9·2	0·695
Education							<0·001
≤12 years	172	57·3	86	86·0	86	43·0	
>12 years	128	42·7	14	14·0	114	57·0	
Family income per capita (Million Rial/month)	1·0	0·5	0·9	0·5	1·0	0·6	0·017
Family history of RA (yes)[c]	7	2·3	3	3·0	4	2·0	0·690
BMI (kg/m^2)	25·6	4·4	27·6	4·8	24·5	3·9	<0·001
WC (m)	0·92	0·12	0·97	0·11	0·90	0·12	<0·001
Supplement intake (yes)[c]	163	54·3	52	52·0	111	55·5	0·566
Smoking (yes)[c]	14	4·7	4	4·0	10	5·0	0·781
Alcohol intake (yes)[c]	12	4·0	3	3·0	9	4·5	0·757
Physical activity (MET-min/d)	145·5	113·6	149·1	117·2	143·8	112·0	0·683
Energy intake (kcal/d)	2089·8	636·8	2194·4	603·2	2037·6	648·0	0·018
DASH components (daily intake/1000 kcal)							
Fruits (g)	178·7	134·4	133·1	100·9	201·5	143·3	<0·001
Vegetables (g)	149·8	109·6	97·4	65·7	176·1	117·6	<0·001
Nuts and legumes (g)	29·3	31·9	17·2	17·5	35·4	35·6	<0·001
Low-fat dairy products (g)	50·9	58·8	34·9	48·8	59·0	61·7	<0·001
Whole grains (g)	24·0	28·3	16·4	23·9	27·9	29·6	<0·001
Sweets (g)	37·7	43·2	45·4	43·7	33·8	42·4	0·027
Red or processed meats (g)	19·2	17·1	23·4	17·1	17·1	16·7	0·003
Sodium (g)	2·0	0·7	2·1	0·6	2·0	0·7	0·734

DASH, the dietary approaches to stop hypertension dietary pattern; MET, metabolic equivalent; RA, rheumatoid arthritis; WC, waist circumference.
[a]Data are presented as *n* (%) or mean ± SD.
[b]The chi-square or Fisher's exact tests were used for comparison of categorical variables and the independent samples *t*-test was used for comparison of continuous variables between RA cases and controls, as appropriate.
[c]These categorical variables were recorded as 'yes/no'.

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Table 2 Characteristics of study participants by tertiles (T) of DASH score (*n* 300)[a,b,c]

	DASH score						
	T1 (*n* 100)		T2 (*n* 100)		T3 (*n* 100)		
Characteristics	T1	%	T2	%	T3	%	*P*
DASH score (range)	8·0–20·0		21·0–27·0		28·0–39·0		
RA	48	48·0	43	43·0	9	9·0	<0·001
Gender							0·136
Male	6	6·0	4	4·0	11	11·0	
Female	94	94·0	96	96·0	89	89·0	
Age (years)	46·3	10·0	48·3	9·0	48·6	9·2	0·167
Education							0·035
≤12 years	64	64·0	61	61·0	47	47·0	
>12 years	36	36·0	39	39·0	53	53·0	
Family income per capita (Million Rial/month)	0·9	0·4	1·0	0·6	1·0	0·5	0·190
Family history of RA (yes)[d]	1	1·0	1	1·0	5	5·0	0·224
BMI (kg/m^2)	25·6	4·4	26·4	4·8	24·7	3·9	0·028
WC (m)	0·91	0·12	0·94	0·12	0·91	0·11	0·083
Supplement intake (yes)[d]	48	48·0	66	66·0	49	49·0	0·016
Smoking (yes)[d]	6	6·0	1	1·0	7	7·0	0·100
Alcohol intake (yes)[d]	3	3·0	1	1·0	8	8·0	0·048
Physical activity (MET-min/d)	141·6	111·5	138·6	105·8	156·4	123·0	0·537
Energy intake (kcal/d)	2056·2	606·2	2087·6	584·5	2125·7	716·2	0·869
DASH components (daily intake/1000 kcal)							
Fruits (g)	97·0	89·4	192·0	116·3	247·1	146·4	<0·001
Vegetables (g)	86·1	57·7	135·2	83·6	228·2	124·2	<0·001
Nuts and legumes (g)	12·3	12·3	21·9	19·0	53·8	40·2	<0·001
Low-fat dairy products (g)	26·3	39·1	40·4	44·6	86·2	70·2	<0·001
Whole grains (g)	7·2	15·0	21·4	26·9	43·6	28·1	<0·001
Sweets (g)	69·1	54·3	27·2	30·1	16·6	14·8	<0·001
Red or processed meats (g)	29·9	20·9	16·0	14·8	11·7	6·4	<0·001
Sodium (g)	2·4	0·6	2·2	0·5	1·6	0·6	<0·001

BMI, BMI; DASH, the dietary approaches to stop hypertension dietary pattern; MET, metabolic equivalent; RA, rheumatoid arthritis; WC, waist circumference.
[a]Data are presented as *n* (%) or mean ± SD, unless stated otherwise.
[b]The χ^2 or Fisher's exact tests were used for comparison of categorical variables and the one-way ANOVA was used for comparison of continuous variables among tertiles of DASH score, as appropriate.
[c]T1, T2 and T3 represent low, medium and high adherence to the DASH dietary pattern, respectively.
[d]These categorical variables were recorded as 'yes/no'.

Table 3 Crude and multivariate-adjusted OR and 95 % CI for RA by tertiles (T) of DASH score (*n* 300)[a,b,c,d]

	DASH score					
		T2 (*n* 100)		T3 (*n* 100)		
RA	T1 (Ref.; *n* 100)	T2	%	T3	%	*P*-trend
Crude	1·00	0·82	[0·47–1·43]	0·11	[0·05–0·24]	<0·001
Multivariable-adjusted model 1	1·00	0·90	[0·48–1·72]	0·09	[0·04–0·22]	<0·001
Multivariable-adjusted model 2	1·00	0·76	[0·38–1·53]	0·08	[0·03–0·20]	<0·001

DASH, the dietary approaches to stop hypertension dietary pattern; RA, rheumatoid arthritis.
[a]T1, T2 and T3 represent low, medium and high adherence to the DASH dietary pattern, respectively.
[b]Crude and multivariable-adjusted OR and 95 % CI for RA by tertiles of DASH score were computed using the binary logistic regression analysis.
[c]Model 1 was adjusted for gender, education, family history of RA, supplement intake, smoking and alcohol intake as potential covariates.
[d]Model 2 was adjusted for covariates in Model 1 as well as for age, family income per capita, BMI, waist circumference, physical activity and energy intake.

non-pharmacological prevention strategies for RA, particularly among adults.

Similar to the evidence from studies using the traditional approach of individual dietary elements, findings of the few studies conducted so far on the potential association of dietary patterns and risk of RA have been mixed and conflicting[37,39–43]. In a prospective cohort study by Hu et al., no significant association was found between adherence to the Mediterranean dietary pattern and risk of RA among adult American women[41]. There were also no significant associations between adherence to the *a-priori* defined dietary patterns (i.e. the Mediterranean diet, the carbohydrate-restricted diet and the healthy diet indicator) and risk of RA among Swedish adults in a nested case–control study by Sundström et al.[42]. In a population-based case–control study among American adults, Comee et al. also failed to find any significant associations between adherence to the Mediterranean dietary pattern or healthy eating

https://doi.org/10.1017/S1368980021003608 Published online by Cambridge University Press

index-2015 and risk of RA[43]. In contrast, greater adherence to the AHEI-2010 was associated with lower risk of RA among adult American women aged ≤55 years in another prospective cohort study by Hu et al.[39]. In addition, Johansson et al. reported an inverse association between adherence to the Mediterranean dietary pattern and risk of RA in a population-based case–control study of Swedish adults[37]. Furthermore, there was a direct association between adherence to the empirical dietary inflammatory pattern (including 18 anti- or pro-inflammatory food or beverage groups weighted by correlations with circulating pro-inflammatory biomarkers) and risk of RA among adult American women aged ≤55 years in a prospective cohort study by Sparks et al.[40]. Similar to the latter three studies, we also found an inverse association between adherence to the DASH dietary pattern and RA in a sample of Iranian adults. Since we are unaware of any previous studies examining the potential association of adherence to the DASH pattern and RA, a direct comparison of the results is not possible at the moment. Nevertheless, our findings are fully supported by those of a series of recent narrative reviews on the role of nutrition in the onset of RA, suggesting that greater adherence to a healthy dietary pattern with almost identical characteristics to the DASH diet might reduce the risk of RA[8,10,11].

According to these review articles, adherence to a plant-based, antioxidant-rich, high-fibre, low-trans and SFA, high-MUFA and low-sodium dietary pattern with a balanced ratio of omega-3 to omega-6 PUFA which is rich in fruits, vegetables, legumes, whole grains, fish and olive oil and poor in high-sugar foods and drinks, red meat and salt could lower the risk of RA development and progression[8,10,11,44]. The DASH diet is quite similar to the above-mentioned dietary pattern and is characterised by high intakes of fruits, vegetables, nuts and legumes, low-fat dairy products and whole grains and low intakes of sweets, red or processed meats and salt[17,19]. Furthermore, it is a plant-based dietary pattern with a favourable omega-3 to omega-6 PUFA ratio which is rich in antioxidants (particularly vitamin C, carotenoids and flavonoids), potassium, magnesium, calcium, fibre and MUFA and poor in sodium, SFA and trans fatty acid[17,19]. Thus, the inverse association between adherence to the DASH pattern and RA in this study further adds to the current evidence on the potential protective effects of healthy dietary patterns against RA.

Although the role of diet in RA pathogenesis is not yet clearly understood, it has been postulated to involve both direct (mainly via modulation of oxidative stress and inflammation) and indirect effects (largely through modifying the risk of obesity and gut microbiota dysbiosis)[8,10,11]. In other words, it seems that adherence to a healthy dietary pattern similar to the DASH diet not only could reduce the risk of RA development and progression by exerting antioxidant and anti-inflammatory effects, but also by contributing to weight control and gut microbiota homeostasis[8,10,11]. The DASH pattern has been reported to decrease the urine F_2-isoprostanes level and increase the plasma total antioxidant capacity and total glutathione levels through its high content of antioxidant nutrients such as vitamin C, carotenoids and flavonoids[21,24]. It has also been shown to lower the serum levels of pro-inflammatory biomarkers such as high-sensitivity C-reactive protein via its high content of anti-inflammatory (i.e. fibre, MUFA, omega-3 PUFA, carotenoids, flavonoids, vitamin C and magnesium) and low content of pro-inflammatory nutrients (i.e. SFA and trans fatty acid)[22]. Moreover, RCT of DASH diet in adults have reported significant reductions in weight, BMI and waist circumference[23], which could be of huge importance in reducing the risk of RA because obesity creates a favourable environment for development of systemic autoimmunity by increasing the production of pro-inflammatory mediators[8,10,11]. Higher adherence to the DASH pattern has also been associated with improved measures of faecal microbial community structure and lower risk of gut microbiota dysbiosis (i.e. a phenomenon linked with increased intestinal permeability and local inflammation which in turn can result in the breaking of immune tolerance to self-antigens and systemic inflammation)[8,25,45]. Finally, as diets high in sugar and sodium have been associated with increased risk of RA via their roles in the development of systemic autoimmunity and inflammation[8,10,11], it seems reasonable to assume that the low content of sugar and sodium in the DASH diet might be at least partially responsible for the potential inverse association between adherence to this dietary pattern and RA.

Some points must be considered when interpreting the results of this study. First, due to the cross-sectional design of the study, causal associations cannot be inferred. Second, because of the high proportion of females in our sample, findings must be cautiously generalised to males. Third, despite all measures taken to avoid selection bias, a few characteristics of this study (e.g. using a convenience sampling method) make it difficult to entirely rule out the possibility of this specific kind of bias. Fourth, even though the evaluation of dietary intakes via dietary records eliminates the possibility of recall bias, it must be noted that reporting bias still remains as a potential concern regarding this particular dietary assessment method. Fifth, although our main statistical analyses were adjusted for several potential covariates, the possibility of residual confounding bias cannot be completely ruled out. Sixth, there is no clear consensus on the best way to construct a DASH score (i.e. which dietary components to include, whether to consider food groups and/or nutrients and how to assign weights to dietary components).

In conclusion, our findings in a sample of Iranian adults revealed that RA patients are less likely than healthy individuals to adhere to the DASH dietary pattern. However, the potential causal association of greater adherence to the DASH pattern and lower risk of RA needs to be confirmed by prospective studies of high methodological

https://doi.org/10.1017/S1368980021003608 Published online by Cambridge University Press

quality among different study populations (e.g. those including a higher proportion of males) around the world. It will also be interesting to find out if high adherence to the DASH dietary pattern could exert any clinically significant therapeutic effects in those already suffering from RA.

Acknowledgements

We would like to express our cordial thanks to participants who dedicated their time for this work. The data presented here were collected by Maryam Ghaseminasabparizi as a part of her doctoral thesis (grant number 97-01-84-19 296 funded by Shiraz University of Medical Sciences).

Financial Support

The present research was financially supported by Shiraz University of Medical Sciences, Shiraz, Iran (grant number 97-01-84-19 296). The funding source had no further role in the present study (i.e. in design, data collection, analysis, drafting of the manuscript or decision to publish).

Conflict of interest

Maryam Ghaseminasabparizi, Mohammad Ali Nazarinia and Masoumeh Akhlaghi declare that they have no conflict of interest; that they have full control of all primary data and that they agree to allow the journal to review their data if requested.

Authorship

All authors made substantial contributions to the conception or design of the work. Maryam Ghaseminasabparizi acquired, analysed and interpreted the data and drafted the work. Mohammad Ali Nazarinia and Masoumeh Akhlaghi revised the work critically for important intellectual content. All authors approved the version to be published.

Ethics of Human Subject Participation

The study protocol was approved by the ethics committee of Shiraz University of Medical Sciences, Shiraz, Iran (ethics approval number IR.SUMS.REC.1398·892). All procedures performed were in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to Participate

Written informed consents were obtained from all participants prior to their inclusion in the study.

Consent for Publication

The authors certify that the consent for publication of this work has been obtained by all co-authors, as well as by the responsible authorities at the institute where the work has been carried out.

Availability of Data and Material

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Code Availability

Not applicable.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980021003608

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