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The association between dietary patterns and disease severity in patients with ulcerative colitis

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Abstract

Ulcerative colitis (UC) is a chronic inflammatory disease involving the colon and rectum. One of the most modifiable environmental factors affecting UC severity is the patient's dietary pattern. Although the role of dietary patterns on UC aetiology has been investigated previously, its relationship with disease severity has not yet been elucidated. This study examined the association between UC patients' dietary patterns and disease severity. This cross-sectional study was conducted in 340 UC patients. Using an FFQ, food patterns were assessed. Twenty-five food categories were categorised based on the similarity of the nutrient composition of the food using the factor analysis method. A simple clinical colitis activity index was used to determine disease severity. Three dietary patterns were identified based on the factor analysis: healthy, unhealthy and Western dietary pattern. After adjusting for potential confounding factors, patients who were in the highest tertile of healthy dietary pattern compared with the lowest tertile were 92 % less likely to have severe UC (OR: 0·08; 95 % CI: 0·03, 0·22). Also, those in the highest tertile of the Western dietary pattern were 3·86 times more likely to have severe UC than those in the lowest tertile (OR: 3·86; 95 % CI: 1·86, 8·00). Even after controlling for confounding variables, unhealthy dietary pattern did not increase the risk of severe UC. Our data indicate the beneficial role of healthy dietary pattern in amelioration of disease severity in UC patients. To confirm this association, more studies are needed, especially prospective cohort studies.

Keywords: Dietary patterns: Disease severity: Ulcerative colitis: Principal component analysis

Ulcerative colitis (UC), Crohn's disease and inflammatory bowel disease unclassified (IBD-U) are all under the category of IBD[1]. Inflammation of the colon's inner lining and other internal organs is a recurring illness known as UC[2,3]. Epidemiological investigations have revealed a noteworthy rise in the occurrence of UC globally[4]. The prevalence of UC has surged from 3·7 million in 1990 to a staggering 6·8 million in 2017[5]. The aetiology of this disease has not yet been understood; however, environmental elements like the type of dietary pattern plays a role in influencing the immune reaction to bacterial components in individuals who have a genetic predisposition[6,7].

Dietary intakes play a crucial role in maintaining equilibrium within the gastrointestinal tract, influencing both the structure and function of the microbiota[8–11]. A growing body of evidence

Abbreviations: IBD, inflammatory bowel disease; UC, ulcerative colitis.

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suggests that IBD is linked to specific dietary patterns, as well as the intake of micro- and macronutrients, along with certain food items[12]. Diet is considered as a potential environmental factor implicated in the origin of IBD[13]. The rise in IBD occurrence has been linked to a dietary shift from the consumption of substantial amounts of healthy plant-based foods to the adoption of energy-dense foods rich in sugar, animal fat and protein in the Westernised diets[14,15]. Moreover, previous studies have shown the association between dietary fermentable oligosaccharides, disaccharides, monosaccharides and polyols and alterations in some IBD symptoms and gut bacterial diversity[16]. In addition, a diet characterised by elevated consumption of sweated beverages and soda has been linked to a higher likelihood of UC[17].

Although there are few studies evaluating the role of diet in IBD development, the precise dietary patterns affecting symptoms and disease activity have not yet been elucidated[18]. Thus, this study is aimed to evaluate the association of dietary patterns with disease severity in patients with UC.

Methods

Study population

The present study was conducted on 340 patients with UC recruited from the Gastroenterology Clinic of Laleh Hospital, Tehran, Iran, using a convenience sampling method. The participants were enrolled between September 2022 and March 2023 and will be followed up for 1 year. A cross-sectional study was conducted using baseline data from an ongoing cohort study. Ethical approval for the present study was obtained from the Ethics Committee of the Shahid Beheshti University of Medical Sciences (No. IR.SBMU.NNFTRI.REC.1401.049). All participants were provided with informed written consent prior to their participation in the current study. Patients with mild or moderately active UC, according to the Simple Clinical Colitis Activity Index[19], or with UC in clinical remission who were aged > 18 years were included in the study. All UC patients were included in the study after being diagnosed by a gastroenterologist and reviewing medical records. Any of the following conditions prevented individuals from participating: patients with gastrointestinal illnesses except UC, cancer, infection, drug addiction, gestation or lactation and recurrence of UC described as Simple Clinical Colitis Activity Index score ≥ 5.

Measurement of ulcerative colitis severity

UC severity was assessed using Simple Clinical Colitis Activity Index, which is a clinical activity indicator that is scored from 0 to 19 and consists of six questions as follows: bowel frequency per day, bowel frequency per night, the urgency of defecation, blood in stool, general well-being and extra-colonic features[19]. Based on Simple Clinical Colitis Activity Index, the severity of UC was categorised into three levels (0–2 remission phase, 3–4 mild/moderate disease and ≥ 5 flare-ups).

Dietary intake assessment

Participants were interviewed in-person using a valid and reliable 168-item semi-quantitative FFQ[20] to investigate their usual food consumption (online Supplementary File 1). After explaining the standard portion size of each food item, participants were asked to report the frequency of intake of each food item given a serving on a daily, weekly, monthly or annual basis, which was then converted to daily intake (in grams) using household measures[21]. As the Iranian food composition table is incomplete, both the Iranian[22] and USDA food composition tables[23] were applied to calculate daily intakes of micro- and macronutrients.

Other variables assessment

Body weight (in kg to the nearest 100 g) was measured using a calibrated digital scale (Seca, Germany), while participants were unshod and in light clothing. Height (in cm to the nearest 0·5 cm) was measured in a standing position, without shoes and with the heels together by the use of a portable stadiometer. Then, the BMI was calculated by dividing weight (kg) by the square height (square meters). To prevent random observer error, the same qualified examiner performed each person's anthropometric measurements. Each person completed a general questionnaire to provide information on their age, sex, smoking status, alcohol consumption, age at diagnosis, level of education and marital status. Medical records were reviewed to gather data on the medical histories of participants including diabetes, CVD and hypertension. The presence of each common symptom and complication of UC, including diarrhea, constipation, abdominal pain and anaemia, was checked through a personal interview. Physical activity was evaluated based on the International Physical Activity Questionnaire-Short Form, whose validity and stability have been previously evaluated in our country[24]. The high-sensitivity C-reactive protein levels were evaluated using an ELISA kit (LDN) that had inter- and intra-assay CV below 7 %. Smoking status was divided into two categories: smokers and non-smokers, which included past smokers and those who never smoked. A person smoking cigarettes or other smoking implements regularly or occasionally was considered as a smoker. Regular drinkers were regarded as alcoholic individuals. Education level was categorised as higher education (with a college education) *v.* lower education (without a college education). When the physical activity level was < 600 metabolic equivalent task minutes per week, subjects were considered physically inactive[25].

Statistical analysis

We classified foods listed in the FFQ into twenty-five food categories based on the similarity of nutrient composition in food items (Table 1). To examine the sample size adequacy and data suitability for factor analysis, Kaiser–Meyer–Olkin and Bartlett's tests were used. As the *P* value for Bartlett test was <0·001 and the Kaiser–Meyer–Olkin test was over 0·71, the correlation among food groups was strong enough to perform factor analysis. To determine major dietary patterns, principal component analysis with a varimax rotation on twenty-five food groups was conducted. Dietary patterns were selected according to the scree plot test and eigenvalues > 1·5. The factor loading of food group was considered positive if there was a positive association between the food group and the pattern, while

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Table 1. Food groups and their loading factors stratified by the type of dietary patterns

	Group details	Dietary patterns		
		Healthy pattern	Unhealthy pattern	Western pattern
Vegetables	Cauliflower, carrot, tomato and its products, spinach, lettuce, cucumber, eggplant, onion, greens, green bean, green pea, squash, mushroom, pepper, corn, garlic, turnip, others	0·679		
Poultry	Chicken	0·642		0·338
Legumes	Lentils, split pea, beans, chick pea, fava bean, soy, others	0·560		0·466
Fruits and fruits juices	Melon, watermelon, honeydew melon, plums, prunes, apples, cherries, sour cherries,peaches, nectarine, pear, fig, date, grapes, kiwi, pomegranate, strawberry, banana,persimmon, berry, pineapple, oranges, dried fruits, all juices, others	0·550		
Fish	All fish types	0·545		
Nuts	Almonds, peanut, walnut, pistachio, hazelnut, seeds, others	0·545		
High fat dairy product	High-fat milk, high-fat yogurt, cream cheese, cream, dairy fat, ice cream, others	0·501	0·425	
Olive and olive oil	Olive and olive oil	0·496		
Egg	Eggs	0·466		0·397
Low fat dairy product	Low-fat milk, skim milk, low-fat yogurt, cheese, curd, yogurt drink, others	0·383		
Potatoes	Potatoes	0·356		
Pickles	Pickle	0·348	0·669	
Sweets and desserts	Cookies, cakes, muffins, pies, chocolates, honey, jam, sugar cubes, sugar, candies, sweet tahini, others		0·591	
Mayonnaise	Mayonnaise		0·552	−0·303
French fries	French fries		0·539	
Snack	Cracker, chips, puff		0·435	
Soft drinks	Soda		0·321	
Cereals	Bread (lavash, barbari, sangak, taftun, biscuits), rice, pasta, biscuits, others			
Pizza	Pizza			
Hydrogenated fats	Hydrogenated vegetable oils, solid fats (animal origin), animal butter, margarine			0·509
Salt	Salt			−0·496
Red or processed meat or Organ meats	Beef and veal, lamb, minced meat, sausage, deli meat, hamburger, Heart, kidney, liver, tongue, brain, offal, rennet			0·400
Vegetable oils	Vegetable oils (except for olive oils)			−0·328
The Broth	Broth			0·323
Tea and coffee	Tea and coffee			
Percentage of variance		13·86	9·28	6·65

Absolute values < 0·30 were not listed in the table for simplicity. Foods or food groups with factor loadings < 0·30 for both factors were excluded.

negative loading of food group implied negative relationship. Food groups with factor loading values over 0·3 were regarded as strongly related to the extracted pattern and were used to label it. After weighting consumption values according to their factor loadings, they were summed to calculate factor scores for each determined dietary pattern[26]. Subsequently, the tertiles of factor scores were used to classify participants. The Kolmogorov–Smirnov normality test was used to assess distributions of continuous variables for normality, and natural logarithm transformations of skewed variables were applied before analyses. Mean and SD and percentages were used to present quantitative and categorical data, respectively. One-way ANOVA and χ^2 tests were applied to detect differences in quantitative and categorical variables among tertiles of dietary patterns, respectively. ANCOVA was also performed to compare disease severity scores across tertiles of dietary patterns. Multivariable logistic regression analysis demonstrated the association between each dietary pattern adherence and disease severity in UC individuals. For these analyses, the lowest tertiles of different dietary patterns were regarded as the reference category. Three models were developed; model 1 was adjusted for age and energy. Further adjustment for sex, education, physical activity, smoking and alcohol was made in model 2. BMI adjustment was added to the previous adjustments in the model. All statistical analyses were performed using SPSS (SPSS Inc., version 23). A P value < 0·05 was considered statistically significant.

Results

Of 340 participants, 61·2 % were women, and the mean (SD) age was 35·8 (11·2) and 37 (12·0) years in men and women, respectively. Three dietary patterns explaining 29·79 % of total consumption variance were determined based on the factor analysis (Table 1): a healthy dietary pattern with a percentage of variance of 13·86 % loading heavily on vegetables, fruits and fruit juices, legumes, nuts, fish, poultry, olive, dairy products, eggs and potatoes; an unhealthy dietary pattern with a percentage of variance of 9·28 % positively associated with a high intake of high-fat dairy, sweets and desserts, French fries, snacks, mayonnaise and soft drinks and a Western dietary patterns having the least percentage of variance (6·65 %) and characterised by the consumption of poultry, legumes, red or processed meat or organ meats, broth and hydrogenated fats, in addition to less consumption of vegetable oils.

Table 2 indicates the baseline characteristics of participants according to the tertiles of dietary pattern scores. Compared with the first tertile of healthy dietary patterns, participants in the last tertile were older and had significantly higher men percent, height, single status, lower BMI and weight. Participants in the greatest tertile of the unhealthy dietary pattern were younger and had higher levels of BMI and height compared with those in the bottom tertile. The levels of weight, BMI, male participants, the ratio of smokers, diabetes, CVD and hypertension were significantly higher in the top tertile of Western dietary pattern participants compared with those in the bottom tertile. Moreover, in the last tertiles of healthy dietary patterns and Western dietary patterns, rate of remission was significantly higher and lower, respectively, in comparison with the first tertiles. However, there was no significant difference in the rate of remission between tertiles of the unhealthy dietary pattern.

The dietary nutrient intakes of participants across all dietary pattern scores are presented in Table 3. Participants in the highest tertile of the healthy dietary pattern had higher intakes of total energy, protein, carbohydrate, fat, dietary fibre, vitamins D, A, E, C, B_1, B_6, B_9, B_{12}, Zn, Ca and Mg, compared with those in the lowest tertile. In addition, dietary intakes of total energy, protein, carbohydrate, fat, dietary fibre, vitamins D, E, C, B_1, B_6, B_9, B_{12}, Zn, Ca and Mg were significantly different between the highest and lowest tertiles of unhealthy dietary pattern. Comparing the first to the last tertiles of the western dietary patterns, we observed significant differences in daily nutrient intakes, in contrast to vitamin D, vitamin B_6, Ca and Mg.

Table 4 presents the multivariable-adjusted means of disease severity scores by tertiles of dietary pattern scores. For the healthy dietary pattern, compared with tertile 1 (T1), T3 had a significantly lower disease severity score ($0·81 \pm 1·07$ *v.* $2·08 \pm 1·55$, $P < 0·001$). For unhealthy and western dietary patterns, the disease severity score of participants in T3 was significantly higher than those in T1 ($1·34 \pm 1·34$ *v.* $1·00 \pm 1·36$, $P = 0·008$ and $2·07 \pm 1·54$ *v.* $0·93 \pm 1·21$, $P < 0·001$, respectively). The differences in high-sensitivity C-reactive protein levels were not significant among tertiles of extracted dietary patterns.

The multivariable-adjusted OR for the odds of severe UC across tertiles of major dietary patterns are illustrated in Table 5. In the crude model, we observed a significant reverse association between following healthy dietary patterns and the odds of severe UC (OR: 0·13; 95 % CI: 0·06, 0·29; $P_{trend} < 0·001$), which was true even when possible confounders including age, energy, sex, education, physical activity, smoking, alcohol and BMI were taken into account in three models (model 1; OR: 0·1; 95 % CI: 0·04, 0·24; $P_{trend} < 0·001$; Model 2; OR: 0·09; 95 % CI: 0·04, 0·22; $P_{trend} < 0·001$; and Model 3; OR: 0·08; 95 % CI: 0·03, 0·22; $P_{trend} < 0·001$). Participants in the highest tertile of the Western dietary patterns score had elevated odds of severe UC compared with those in the bottom tertile (OR: 3·12; 95 % CI: 1·65, 5·87; $P_{trend} < 0·001$). This relationship was unchanged following age and energy adjustments (OR: 3·47; 95 % CI: 1·8, 6·67; $P_{trend} < 0·001$). No significant changes in OR were detected after adjustment for other potential confounders, including sex, education, physical activity, smoking, and alcohol (OR: 4·07; 95 % CI: 2·02, 8·21; $P_{trend} < 0·001$). In the third model, this association continued to be significant (OR: 3·86; 95 % CI: 1·86, 8·00; $P_{trend} < 0·001$). However, no significant relationship was found between unhealthy dietary patterns and the odds of severe UC (OR: 1·25; 95 % CI: 0·64, 2·42; $P_{trend} = 0·51$) even after adjustment for confounders including age, energy, sex, education, physical activity, smoking, alcohol, and BMI (OR: 1·51; 95 % CI: 0·72, 3·18; $P_{trend} = 0·26$).

Discussion

To our knowledge, this study is the first one to examine the association between adherence to various dietary patterns and disease severity in Iranian patients with UC. In this cross-sectional study, we identified three dominant dietary patterns in UC patients in clinical remission as follow: healthy, unhealthy and Western dietary patterns. Adherence to a healthy dietary pattern was linked with lower odds of active symptoms of UC. Despite lack of observation of any association between unhealthy dietary pattern and UC activity scores, those following the Western dietary pattern experienced increased disease activity.

Previous observational studies have provided several pieces of evidence showing that diet can influence UC severity. Some vegetables, fruits, legumes, beans, spicy foods, milk, dairy products, alcohol and sweetened beverages are among the most common foods associated with worsened UC symptoms[17,27–29]. In contrast, rice and yogurt have been reported to ameliorate the severity of UC symptoms[17]. However, the better approach for examining diet in relation to chronic disorders is in the form of dietary patterns to capture whole interactions within the diet rather than considering the intake of a single food group [30,31]. In the current investigation, we extracted three data-driven dietary patterns in Iranian adults diagnosed with UC; (1) healthy dietary pattern which was characterised by high intakes of vegetables; fruits, and fruit juices; legumes; nuts; fish and poultry; (2) unhealthy dietary pattern which contained high amounts of sweets and desserts; French fries; snacks and mayonnaise and (3) Western dietary pattern which was rich in red or processed meat or organ meats and hydrogenated fats. What we found was not quite similar to dietary patterns extracted in previous studies conducted in Iran[7,32,33]. The differences can be elucidated by the fact that the dietary intakes of UC patients are rather different from those of the general population[29,34,35]. A recent meta-analysis and systematic review of observational studies summarising the dietary intakes of IBD patients reported inadequate dietary intakes of energy, fibre, folate, Ca, legumes, fish, fruit and vegetables and dairy products, as well as excessive dietary intakes of Na and added sugar in UC patients in remission[36]. Comparing the habitual dietary intakes of UC patients with what is established as the usual dietary patterns of

Table 2. Baseline characteristics of study patients based on tertiles of major dietary patterns

	Healthy pattern score					Unhealthy pattern score					Western pattern score				
	1 (lowest)		3 (highest)			1 (lowest)		3 (highest)			1 (lowest)		3 (highest)		
	Mean	SD	Mean	SD	P*	Mean	SD	Mean	SD	P*	Mean	SD	Mean	SD	P*
Age (year)	36·3	9·50	38·2	12·4	0·13	40·0	13·5	34·3	10·8	<0·001	37·6	12·2	36·6	10·1	0·38
Age at diagnosis (years)	27·6	7·18	28·5	9·21	0·03	28·3	9·42	26·7	7·54	0·27	28·0	9·48	27·7	6·93	0·14
Height (cm)	163	8·09	169	10·3	<0·001	165	9·79	169	9·54	0·01	167	9·43	168	10·0	0·06
Weight (kg)	78·1	14·7	74·9	15·1	0·001	71·7	15·1	74·6	15·8	0·05	71·0	13·8	79·7	15·7	<0·001
BMI (kg/m^2)	29·1	5·57	26·1	4·61	<0·001	26·0	4·83	26·1	5·29	0·01	25·4	4·30	28·1	5·63	<0·001
	%		%			%		%			%		%		
Sex, male (%)	28·3		44·2		0·02	32·7		46·0		0·11	37·2		48·7		0·01
Marital Status (single) (%)	31·9		39·8		0·01	37·2		46·9		0·27	39·8		39·8		0·85
Physical activity (inactive) (%)	53·1		44·2		0·13	45·1		43·4		0·87	45·1		41·6		0·51
Education (higher education) (%)	61·9		68·1		0·39	64·6		55·8		0·10	69·0		63·7		0·17
Smoking (smoker) (%)	10·6		16·8		0·07	17·7		19·5		0·31	12·4		24·8		0·01
Alcohol (yes) (%)	0·00		3·50		0·07	1·80		1·80		0·81	0·90		1·80		0·81
Diabetes (yes) (%)	6·20		1·80		0·24	1·80		2·70		0·37	0·90		9·70		0·001
CVD (yes) (%)	6·20		3·50		0·52	1·80		8·00		0·06	1·80		10·6		<0·001
Hypertension (yes) (%)	5·30		1·80		0·08	3·50		2·70		0·70	0·00		6·20		0·01
Anemia (yes) (%)	4·40		7·10		0·58	7·10		4·40		0·58	7·10		4·40		0·58
Diarrhea (yes) (%)	14·2		16·8		0·85	15·0		15·0		0·92	22·10		11·5		0·06
Constipation (yes) (%)	0·90		3·50		0·35	2·70		2·70		0·55	1·80		1·80		0·87
Abdominal pain (yes) (%)	5·30		3·50		0·65	3·50		8·00		0·20	4·40		4·40		0·79
Disease severity (Remission) (%)	61·1		92·0		<0·001	82·3		78·8		0·36	84·1		62·8		<0·001

BMI, body mass index; CVD, cardiovascular disease; kg, kilogram; Cm, centimeter; kg/m^2, kilogram/meter^2; MET/min/week, metabolic equivalent minute per week Values are based on mean ± standard deviation or reported percentage.
* Obtained by one-way ANOVA or chi-square, where appropriate.

Table 3. Daily nutrient intake of all patients across tertiles of dietary patterns

	Healthy pattern score					Unhealthy pattern score					Western pattern score				
	1 (lowest)		3 (highest)			1 (lowest)		3 (highest)			1 (lowest)		3 (highest)		
	Mean	SD	Mean	SD	*P**	Mean	SD	Mean	SD	*P**	Mean	SD	Mean	SD	*P**
Energy (kcal/d)	2011	839	2800	872	<0·001	2035	817	2786	926	<0·001	2172	727	2556	904	<0·001
Protein (g/d)	67·3	28·8	111	65·0	<0·001	80·4	65·4	98·1	38·8	<0·001	74·4	28·8	100	66·5	<0·001
Carbohydrate (g/d)	307	142	375	111	<0·001	289	96·1	387	145	<0·001	307	101	351	112	0·016
Fat (g/d)	59·0	26·8	100	42·8	<0·001	65·7	38·8	98·6	40·7	<0·001	76·3	39·8	86·7	41·2	0·001
Dietary fibre (g/d)	6·51	1·93	14·64	5·34	<0·001	10·7	6·20	10·8	4·77	<0·001	10·8	5·19	10·0	5·33	0·03
Vitamin D (μg/d)	0·99	1·40	2·30	2·81	<0·001	1·70	3·00	2·01	1·85	0·01	1·40	1·12	2·03	2·82	0·06
Vitamin A (RAE/d)	973	625	1928	1234	<0·001	1254	1074	1450	1045	0·20	1320	1115	1521	1009	0·006
Vitamin E (mg/d)	4·94	3·22	8·61	5·85	<0·001	5·21	3·18	8·84	6·07	<0·001	6·89	5·37	6·82	4·86	0·04
Vitamin C (mg/d)	78·4	29·3	177	74·5	<0·001	131	84·7	127	66·3	0·005	132	72·5	124	69·7	0·01
Vitamin B_1 (mg/d)	2·01	1·13	2·37	0·81	<0·001	1·88	0·72	2·40	1·20	<0·001	1·90	0·68	2·26	0·76	0·01
Vitamin B_6 (mg/d)	1·23	1·12	2·27	1·03	<0·001	1·66	1·07	1·96	1·25	<0·001	1·64	0·78	1·75	1·09	0·41
Vitamin B_9 (μg/d)	220	65·1	408	193	<0·001	296	206	330	143	0·004	276	11	338	207	0·002
Vitamin B_{12} (μg/d)	2·96	1·44	5·61	3·34	<0·001	4·17	3·34	4·63	2·30	0·006	3·74	1·98	4·86	3·21	0·001
Zinc (mg/d)	7·60	2·90	13·1	7·41	<0·001	9·53	7·44	11·2	4·51	0·001	8·68	3·26	11·7	7·65	<0·001
Calcium (mg/d)	696	484	1156	547	<0·001	815	499	1094	585	<0·001	875	472	938	544	0·46
Magnesium (mg/d)	201	68·9	361	132	<0·001	256	138	315	112	<0·001	264	99·5	284	142	0·14

* Obtained by one-way ANOVA.

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Table 4. Multivariable adjusted means for disease severity score and hs-CRP across tertiles (T) of major dietary patterns

Tertiles of major dietary patterns							
	Healthy pattern score						
	T1		T2		T3		
	Mean	SD	Mean	SD	Mean	SD	*P*
Disease severity score	2·08	1·55	1·08	1·24	0·81	1·07	<0·001
Hs-CRP	2·00	1·62	2·88	5·53	2·17	2·07	0·44
	Unealthy dietary score						
	T1		T2		T3		
Disease severity score	1·00	1·36	1·64	1·45	1·34	1·34	0·008
Hs-CRP	2·49	4·46	2·40	3·79	2·18	1·94	0·93
	Western dietary score						
	T1		T2		T3		
Disease severity score	0·93	1·21	0·97	1·14	2·07	1·54	<0·001
Hs-CRP	2·97	5·58	1·88	1·34	2·22	2·17	0·18

Hs-CRP, high-sensitivity C-reactive protein.
P ANCOVA test adjusted for age, sex, education, physical activity, smoking, alcohol, total energy and BMI.

Table 5. Multivariable adjusted odds ratios and 95 % confidence intervals of severe disease across tertiles (T) in relation to major dietary patterns

	Tertiles of major dietary patterns					
	Healthy dietary Pattern					
		T2		T3		
	T1	OR	95 % CI	OR	95 % CI	*P**
Crude	1·00	0·33	0·18, 0·61	0·13	0·06, 0·29	<0·001
Model 1	1·00	0·31	0·17, 0·59	0·10	0·04, 0·24	<0·001
Model 2	1·00	0·30	0·15, 0·57	0·09	0·04, 0·22	<0·001
Model 3	1·00	0·28	0·14, 0·56	0·08	0·03, 0·22	<0·001
	Unealthy dietary Pattern					
	T1	T2		T3		
Crude	1·00	1·58	0·83, 3·01	1·25	0·64, 2·42	0·51
Model 1	1·00	1·55	0·81, 2·98	1·28	0·61, 2·66	0·47
Model 2	1·00	1·64	0·84, 3·19	1·51	0·72, 3·17	0·25
Model 3	1·00	1·49	0·76, 2·94	1·51	0·72, 3·18	0·26
	Western dietary Pattern					
	T1	T2		T3		
Crude	1·00	0·67	0·31, 1·46	3·12	1·65, 5·87	<0·001
Model 1	1·00	0·66	0·30, 1·43	3·47	1·80, 6·67	<0·001
Model 2	1·00	0·68	0·31, 1·51	4·07	2·02, 8·21	<0·001
Model 3	1·00	0·68	0·30, 1·48	3·86	1·86, 8·00	<0·001

Data are presented as OR and 95 % CI.
Model 1; Adjusted for age and energy.
Model 2; Adjusted for age, energy, sex, education, physical activity, smoking, and alcohol.
Model 3: Adjusted for age, energy, sex, education, physical activity, smoking, alcohol, and BMI.
* Obtained from binary logistic regression.

the Iranian population, the dietary patterns observed in this study are reasonable. In this survey, individuals with higher adherence to healthy dietary pattern were older compared with the others. This is understandable considering the fact that consumption of unhealthy food items is greater among youths as a result of nutrition transition around the world[37]. Moreover, subjects who followed unhealthy and Western dietary patterns had higher BMI. According to previous reports, Western dietary pattern is strongly associated with general and central adiposity in the Iranian population[38]. As expected, a higher percentage of chronic disease history was observed in the highest tertile of Western dietary pattern[39,40]. In this study, the dietary pattern labeled as healthy was associated with lower chances of UC active symptoms, while an unhealthy dietary pattern was not linked with UC severity. We also observed that in individuals following Western dietary patterns, the disease symptoms worsened. Some previous studies have found different results. Limketkai et al.[41] have reported that a dietary cluster that resembled the Western diet was not associated with lower odds of active symptoms of UC, whereas plant-based dietary patterns, which were similar to the healthy dietary patterns extracted in this study, decreased the risk of UC active symptoms. A prospective cohort study has shown that among three extracted dietary patterns, only the first one, characterised by high consumption of grains, potatoes, oils and fats, processed and red meats, sugar and pastries, which was labelled 'traditional [Dutch]', was associated with the occurrence of flares in IBD patients. Researchers in that study claimed that this traditional dietary pattern resembled Western dietary patterns. Interestingly, in the same study, a Mediterranean-like diet was not linked with flares in IBD patients[42]. This disparity could be justified by different methods applied to assess dietary intakes, extract dietary patterns and perform statistical analysis.

How exactly diverse dietary patterns and their components are related to UC severity is not fully understood yet. However, diet can modulate symptoms of UC through several possible mechanisms. Since a dysregulated gut microbiota can decrease the defensive and immunomodulatory functions of the intestine[43], alterations in gut microbiota have significant beneficial effects on intestine health[44]. Diet can reshape the gut microbiota[45,46], and thus modulate UC symptoms. Diet also can lessen the intestinal inflammation due to its anti-inflammatory and antioxidative properties[47,48]. Dietary components have been found to improve mucosal immunity and epithelial barrier integrity as well[15,49]. Another possible significance of diet in the course of UC is malnutrition, which is common among UC patients[50,51]. Micronutrient deficiencies and protein-energy malnutrition can indeed affect the course of IBD[52,53].

The main strengths of this study are focusing on dietary patterns rather than single nutrients or food items and being the first study to evaluate the association of posterior dietary patterns and the severity of UC in the Iranian population. Some strengths and limitations of the present study go hand in hand. For instance, applying a validated and detailed FFQ to assess the usual dietary intake of people suffering from UC is one of this study's strengths; however, misclassification of study participants is still a possibility.

Moreover, even though several potential covariates were accounted for in multivariable models, there is always the effect of unmeasured residual confounders. Additionally, although, we used a validated questionnaire to assess disease severity, we did not gather any endoscopic data to apply other scores such as Mayo endoscopic score or UC endoscopic index of severity. Other limitations of this study include (1) reverse causality due to cross-sectional design of the present study; (2) subjective decisions made by researchers that are inbred during factor analysis, for example, subjective decisions are made regarding the number of food patterns[54] and (3) possible changes in usual dietary intake of patients with a purpose of easing UC symptoms. Further prospective cohort studies are needed in order to further assess our findings.

In conclusion, in this cross-sectional study, we found that adherence to a healthy dietary pattern might lower the odds of active symptoms in UC patients. Furthermore, the Western dietary pattern increased disease activity in these patients. More studies, especially prospective cohort studies, are needed to further assess this association.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the Shahid Beheshti University of Medical Sciences (No. IR.SBMU.NNFTRI.REC.1401.049). Written informed consent was obtained from all subjects/patients.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114524000187

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