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Association between plant-based dietary index and disease severity in patients with ulcerative colitis: a cross-sectional study

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Abstract

Background Plant foods are naturally rich in anti-inflammatory nutrients. In this cross-sectional study, we assessed the association between the plant-based dietary index (PDI) and Mayo score in patients with ulcerative colitis (UC).

Methods This analytical cross-sectional study included 158 patients with UC. The Mayo score was used to determine disease severity. An expert nutritionist performed the anthropometric assessments. A 168-item quantitative food frequency questionnaire (FFQ) was used to calculate the PDI, healthy PDI (hPDI), and unhealthy PDI (uPDI). To assess the association between the total Mayo score (as a dependent factor) and different indices of PDI (as an independent variable), the linear regression model was used.

Results The mean age of participants was 42.52 ± 12.61 years. There were significant differences in the total Mayo score between tertiles of PDI score ($p = 0.02$). The result of linear regression showed that in the unadjusted model, compared with the patients in the first tertile of PDI, the patients in the second (-0.21 (-1.89, -0.17)), and third tertile (-0.21 (-1.95, -0.16)) had significantly lower total mayo scores. The inverse association remained significant after adjusting for covariates. However, uPDI and hPDI tertiles were not significantly associated with total Mayo scores in the adjusted and unadjusted models.

Conclusion higher PDI was significantly associated with higher UC severity. However, considering the limitations of the study, more cohort studies are needed to confirm these results.

Keywords Plant-based dietary index, Disease severity, Ulcerative colitis, Inflammatory bowel disease

Introduction

Ulcerative colitis (UC) is an autoimmune disease characterized by colon and rectum inflammation during flare-ups and recurrence [1]. The flare-up period is accompanied by higher levels of inflammatory biomarkers and worse clinical manifestations [2]. Studies have indicated that different factors, such as smoking, specific infectious agents, and stress could affect the course of the disease [3]. Various studies have also shown that dietary components can affect intestinal inflammation, microbiota, immunity, and mucosal barrier function, thereby affecting the disease course in ulcerative colitis patients

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[4–11]. For example, a diet high in sugar, fat, fast food, and animal products and low in fruits and vegetables may contribute to intestinal inflammation and consequently higher disease activity in ulcerative colitis [9]. In a case-control study, low dietary fiber and high animal food and sugar consumption were correlated with UC [10].

In this regard, some studies assessed the effect of a plant-based diet (PBD) on relapse prevention in patients with UC and showed that PBD was effective in relapse prevention in patients with mild UC [12]. In another study, the combination of PBD and infliximab prevented relapse in severe UC patients [13]. In other inflammatory conditions, an inverse association between PBD and C-reactive protein levels has been reported [14]. These studies have considered all plant-based foods in a category; however, some of these foods, such as refined grains and sugar-sweetened beverages, have unfavorable effects on human health [15, 16]. Thus, an index that separates healthy from unhealthy plant foods could provide better insight into the association between PBD and the severity of ulcerative colitis.

Considering that plant foods are naturally rich in anti-inflammatory nutrients, such as antioxidants, omega-3 fatty acids, and fiber, we postulated that there may be an association between the plant-based dietary index (PDI), healthy PDI (hPDI), and unhealthy PDI (uPDI) and disease activity in patients with UC. From what we know, no studies have assessed this association. Therefore, this cross-sectional study assessed the association between different PDI indices and Mayo scores in patients with UC.

Methods

In this analytical cross-sectional study, patients were recruited from the inflammatory bowel disease clinic of Imam Reza Hospital, Tabriz University of Medical Sciences. Patients were included in this study if they were aged 20–60 years old, and the UC was diagnosed at least 6 months before the study. Patients were excluded from the study if they had other gastrointestinal diseases, cancers, and autoimmune diseases or diseases requiring special diets, such as diabetes, cardiovascular diseases, and celiac diseases. Based on these criteria, 164 consecutive patients who were referred to the IBD clinic from April 2022 to February 2023 were eligible to participate in the study. However, four patients did not consent to participate in the study, and three patients had incomplete information; thus, the final analysis included data from 158 patients |(Fig. 1).

UC was diagnosed by an expert gastroenterologist according to the criteria of Truelove and Witts based on clinical, endoscopic, radiological, and histological findings [17].

The Power Analysis & Sample Size (PASS) software (PASS 2021, NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/pass) was used to calculate the sample size. For this purpose, we used a power of 80%, a confidence level of 95% and the results of a similar study conducted by Jowet et al. [18] about the association of dietary intake of food groups and relapse in UC.

All patients provided an informed consent form, and the study was approved by the ethics committee of Tabriz University of Medical Sciences (Ethics code: IR.TBZMED.REC.1402.828).

Information regarding the patients' gender (male, female), age (year), educational level (illiterate, subdiploma, diploma, and university education), marital status (married, and single), smoking (current smoker or not), and alcohol consumption (current drinker or not) was collected through general information questionnaires.

Disease-related information such as disease duration (years), and extension (Ulcerative proctitis, Left-sided colitis, Proctosigmoiditis, Pancolitis), treatments (Mezalazine, Azathioprine, Prednisolone), and supplements (any vitamins, minerals, omega 3 fatty acid) use were recorded by an expert gastroenterologist and endoscopist.

The Mayo score was used to determine disease severity. The Mayo score was first proposed in 1987 by Schroeder et al. in a clinical trial of 5-aminosalicylate drugs in UC and has since been used in various subsequent clinical trials and practices [19]. For the calculation of this score, an expert gastroenterologist pooled the scores of rectal bleeding (0–3), stool frequency (0–3), physician's global assessment (0–3), and endoscopy findings (0–12) and calculated the total Mayo score. Higher scores indicate greater disease severity. The last Mayo score of the patients was obtained from an expert gastroenterologist and endoscopist.

To assess anthropometric status, an expert nutritionist measured body weight and height using standard protocols and calibrated instruments.

Dietary assessment and PDI calculation

In 2016, the plant-based dietary index (PDI), healthy PDI (hPDI), and unhealthy PDI (uPDI) were introduced. These indices are measures of obedience to a general PBD and healthy and unhealthy PBD, respectively [20, 21]. For the evaluation of dietary factors, an expert nutritionist completed a 168-item quantitative food frequency questionnaire (FFQ) through face-to-face interviews. For calculating dietary scores, the daily, weekly, or monthly amount of food items consumed by each participant were recorded, and then all amounts were converted into daily consumption to develop three types of PDIs: overall PDI, healthy PDI (hPDI), and unhealthy PDI

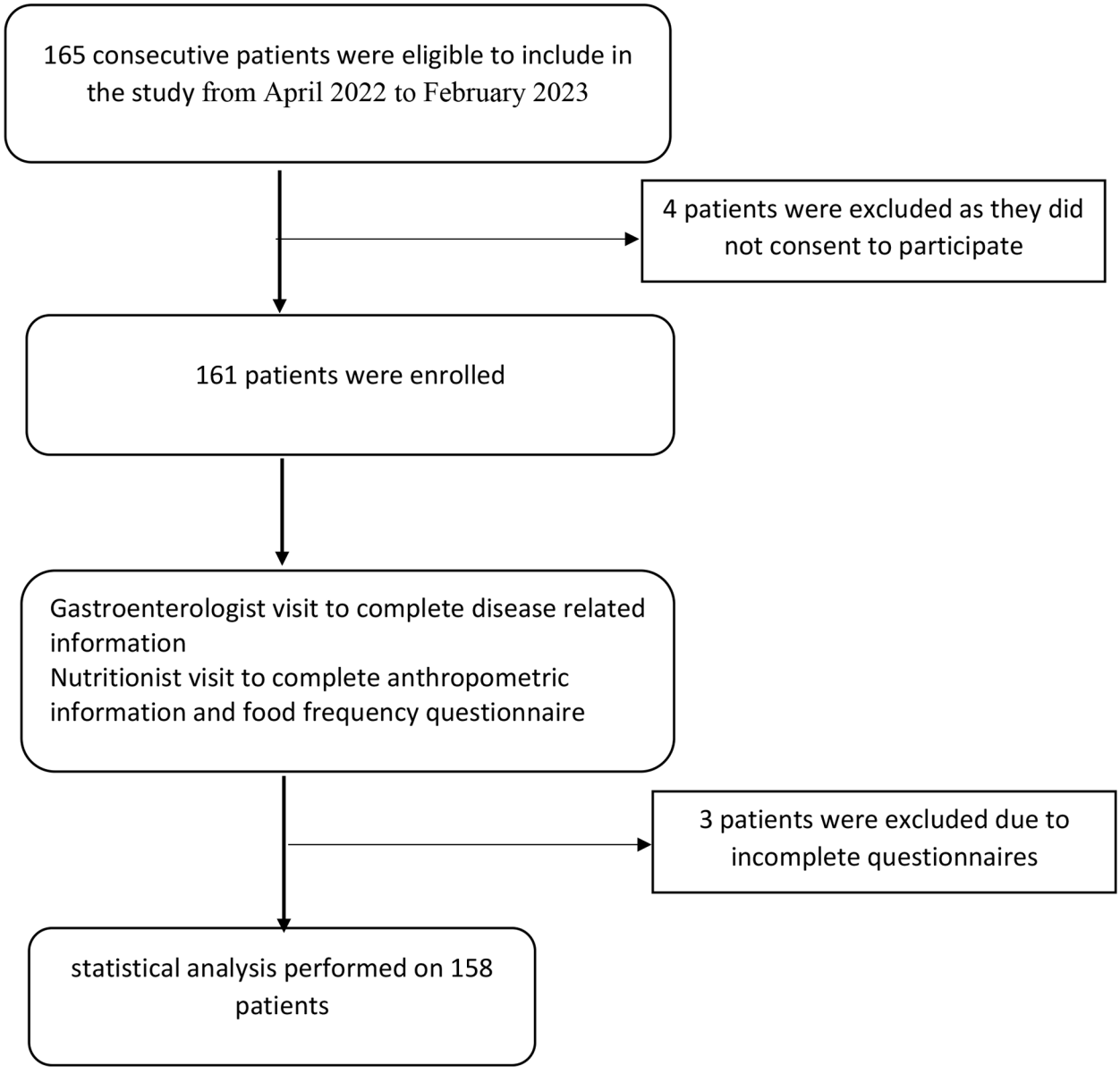

Fig. 1 Flowchart of patients inclusion

(uPDI). To calculate these indices, 18 food groups based on nutrient and culinary similarities were defined. Food groups and their constituent food items are presented in Supplementary Table 1. According to their food intake, patients were arranged into quintiles and assigned negative or positive scores. Patients in the highest quintile of a given food group were given a reward of five, whereas those in the lowest quintile were given a reward of one. The reverse scoring pattern was also calculated. To calculate the PDI, we gave a positive score for all plant-based food categories and a negative score for all animal-based food categories. In terms of hPDI, the positive values were assigned to healthier plant-based food groups, and negative values were assigned to less healthy plant-based food groups and animal-based food groups. for uPDI calculation, the positive values were assigned to unhealthy plant food categories, and negative values were assigned to healthy plant food categories and animal food groups. The allocated scores for each food group were summed, and the indices were analyzed as deciles, with energy intake adjusted at the time of analysis.

Statistical analysis

For assessing the distribution of data, the Kolmogorov-Smirnov test was applied. The data were presented as mean and standard deviation (SD) (continuous data) or

number and percentage (categorical data). Between-group comparisons were conducted using the chi-square test (for the nominal variable), one-way analysis of variance (for normally distributed variables), and the Kruskal-Wallis Test (non-normally distributed variables). To assess the association between the total Mayo score (as a dependent factor) and different indices of PDI (as an independent variable), the linear regression model was used. The model was adjusted for the potential covariates: (age, sex, smoking, drinking alcoholic beverages, disease duration, prednisolone use, dietary supplements use, and BMI). All analyses were performed using SPSS version 21, and a p-value of 0.05 was considered significant.

Results

Participants' characteristics

The mean age of participants was 42.52±12.61 years, 46.8% were female, 55.1% had left-sided colitis, and 6.3% had pancolitis. The demographic and disease-related characteristics of the participants across the PDI, hPDI, and uPDI tertiles are presented in Table 1. Although participants were similar regarding most demographic and disease-related variables across the PDI, hPDI, and uPDI tertiles, there were significant differences in total Mayo score ($p=0.02$) and prednisolone use ($p=0.03$) across the PDI tertiles. Regarding the hPDI score, there were significant differences between the groups concerning BMI ($p=0.004$). There were significant differences between the uPDI tertiles in age ($p=0.04$), BMI ($p=0.005$), and smoking status ($p=0.02$).

Table 2 presents the risk difference (RD) estimates from the linear regression analysis of the association between PDI score and disease severity. The result showed that in the unadjusted model, compared with the patients in the first tertile of PDI, the patients in the second (RD: -0.21, 95%CI (-1.89, -0.17)), and third tertiles (RD: -0.21 95%CI(-1.95, -0.16)) had significantly lower total mayo scores. The inverse association remained significant after adjusting for covariates. However, no significant association was observed between uPDI, hPDI tertiles, and total Mayo score in the adjusted and unadjusted models.

Discussion

Considering the importance of dietary factors on disease severity in patients with UC, the present study assessed the association between the plant-based dietary pattern and the total mayo score, which is an indicator of disease severity. Results showed that for every one unit increase in PDI score, the mayo score was decreased by 0.21 units. Previously, the relapse prevention effect of PBD was demonstrated in patients with UC [12, 13, 22].

For every one unit increase in admission hemoglobin level, the median length of stay was reduced by 0.5 day.

The inverse association between PDI and the severity of UC may be partly due to the decrease in inflammation caused by plant-based foods. In a systematic review and meta-analysis, the effects of PBD on interleukin-6 and C-reactive protein levels in obese individuals were demonstrated [23]. An interventional study of patients with type 2 diabetes indicated that treatment could decrease serum calprotectin [24]. Moreover, previous studies have indicated that high dietary sulfur intake is associated with an increased relapse risk of UC [17]. Considering the high content of sulfur-containing amino acids, such as methionine and cysteine, in eggs, meat, and poultry, PBD can reduce disease severity in UC in this manner. Studies have indicated that plant protein intake along with a high-quality diet could reduce homocysteine levels [25] and, consequently, inflammation in patients with UC.

The differences in the fatty acid content of plant-based, and animal-based diets could also partly illustrate the significant inverse association between PBD and disease severity in UC. PBD has a lower content of Short-chain fatty acids (SFA) and a higher content of mono- and polyunsaturated fatty acids. Earlier studies indicated that SFA could increase tissue cytokine levels; however, polyunsaturated fatty acids, eicaso-pentaenoiec acid, and decasopentaenoiec acid had an inverse effect in patients with UC [26].

We did not observe any association between uPDI and hPDI and disease severity. This observation may be due to the inclusion of foods such as fish and seafood in this index. Previous studies have shown that seafood oil can reduce inflammation and oxidative stress in patients with UC [27] which may be partly due to the high omega-3 fatty acid content in these foods [26]. In addition, the uPDI also includes 100% fruit juices. Fruit juices are a good source of phytochemicals [28, 29]. Various investigations have shown the positive effect of phytochemicals against inflammatory factors and inflammation-associated diseases [30]. A positive association between 100% fruit juice consumption and UC remission has been reported [31, 32].

The present study had some strengths, such as considering different confounding factors in the regression analysis, being the first study to assess the association between PDI and disease severity among patients with UC, and assessing the dietary pattern using a valid FFQ and energy-adjusted values for all food groups. However, some limitations should be considered. First, this was a cross-sectional study, and the causality effect could not be inferred and was susceptible to recall bias. Second, although we considered different confounding factors in the regression analysis, some unidentified and residual covariates that could lead to confounding bias could not be controlled. Moreover, factors such as storage and

Table 1 Demographic and disease related characteristics of participants across tertiles of PDI, hPDI, and uPDI score

Variables	PDI			*p*-value	hPDI			*P*-value	uPDI			*p*-value
	T1 (*n* = 52)	T2 (*n* = 57)	T3 (*n* = 49)		T1 (*n* = 47)	T2 (*n* = 64)	T3 (*n* = 47)		T1 (*n* = 54)	T2 (*n* = 50)	T3 (*n* = 54)	
Age (years)	41.94 ± 14.04	44.46 ± 12.72	40.88 ± 10.70	0.32	40.06 ± 12.37	42.52 ± 12.78	44.98 ± 12.41	0.16	45.96 ± 11.91	41.30 ± 12.88	40.212.52	0.04
Sex (male)	28 (53.8)	32 (56.1)	24 (49)	0.76	25 (53.2)	33 (51.6)	26 (55.3)	0.94	25 (46.3)	27 (54)	32 (59.3)	0.41
BMI (Kg/m^2)	25.50 ± 3.67	25.77 ± 3.75	26.18 ± 5.56	0.73	25.38 ± 4.11	24.85 ± 3.13	27.54 ± 5.45	0.004	27.35 ± 5.32	24.91 ± 3.09	25.09 ± 3.89	0.005
BMI categories												
< 18.5 (Kg/m^2)	1 (1.9)	2 (3.5)	2 (4.1)	0.91	3 (6.4)	1 (1.6)	1 (2.1)	0.25	2 (3.7)	0 (0)	3 (5.6)	0.09
18.5-24.99 (Kg/m^2)	25 (48.1)	23 (40.4)	21 (42.9)		21 (44.7	32 (50)	16 (34)		17 (31.5)	25 (50)	27 (50)	
≥ 25 (Kg/m^2)	26 (50)	32 (56.1)	26 (53.1)		23 (48.9)	31 (48.4)	30 (63.8)		35 (64.8)	25 (50)	24 (44.4)	
Disease duration (Month) median (range)	6.5 (35)	6 (24)	7 (18)	0.58	8 (35)	7.5 (24)	6 (24)	0.81	7 (24)	5.5 (24)	8 (35)	0.38
Total mayo score	6.38 ± 2.31	5.35 ± 2.17	5.33 ± 2.34	0.02	6.19 ± 2.27	5.39 ± 2.21	5.57 ± 2.45	0.18	5.33 ± 2.30	5.86 ± 2.53	5.87 ± 2.11	0.39
Current smoker	10 (19.2)	6 (10.5)	6 (12.2)	0.44	8 (17)	11 (17.2)	3 (6.4)	0.24	2 (3.7)	9 (18)	11 (20.4)	0.02
Current Alcoholic drinks consumers	3 (5.8)	2 (3.5)	1 (2)	0.68	3 (6.4)	3 (4.7)	0 (0)	0.32	0 (0)	2 (4)	4 (7.4)	0.12
Nutritional supplements use	48 (92.3)	48 (84.2)	42(85.7)	0.41	42 (89.4)	58 (90.6)	38 (80.9)	0.27	45 (83.3)	44 (88)	49 (90.7)	0.50
Treatments												
Mezalazine	52 (100)	57(100)	49(100)	-	47 (100)	64 (100)	47 (100)	-	54 (100)	50 (100)	54 (100)	-
Azathioprine	35 (67.3)	34 (59.6)	39 (79.6)	0.08	32 (68.1)	45 (70.3)	31 (66)	0.88	37 (68.5)	34 (68)	37 (68.5)	0.99
Prednisolone	19 (34.6)	15 (24.6)	25 (51)	0.03	22 (46.8)	18 (28.1)	19 (40.4)	0.11	20 (37)	15 (30)	24 (44.4)	0.31
Disease extension												
E1	3 (5.8)	4 (7)	9 (18.4)	0.21	2 (4.3)	6 (9.4)	8 (17)	0.02	8 (14.8)	6 (12)	2 (3.7)	0.08
E2	45 (86.5)	50 (87.7)	37 (75.5)		42 (89.4)	56 (87.5)	344 (72.4)		41 (76)	42 (84)	49 (90.7)	
E3	4 (7.7)	3 (5.3)	3 (6.1)		3 (6.4)	2 (3.1)	5 (10.6)		5 (9.3)	2 (4)	3 (5.6)	

PDI: plant based dietary index; hPDI: healthy plant based dietary index; uPDI: unhealthy plant based dietary index; BMI: body mass index

Normally distributed Continuous variables are in mean ± SD, non-normally distributed variables are in median(range), and categorical and nominal variables are in frequency (%)

Between-group comparisons of continues, and categorical and nominal variable were done by one-way ANOVA (normally distributed variables) and Kruskal-Wallis Test (non-normally distributed variables), and chi-square respectively

Table 2 Linear regression analysis for disease severity according to tertiles of PDI, hPDI, and uPDI

Variables	Total mayo score			
	Unadjusted model		Adjusted model*	
	B (95%CI)	*p*-value	B (95CI)	*p*-value
PDI				
tertile 1 (n = 52)	1	-	1	-
tertile 2 (n = 57)	-0.21 (-1.89, -0.17)	0.01	-0.21 (-1.90, 0.12)	0.02
tertile 3 (n = 49)	-0.21 (-1.95, -0.16)	0.02	-0.22 (-2.04, -0.20)	0.01
hPDI				
tertile 1 (n = 47)	1	-	1	-
tertile 2 (n = 64)	-0.17 (-1.67, 0.07)	0.07	-0.15 (-1.62, 0.19)	0.12
tertile 3 (n = 47)	-0.12 (-1.55, 0.32)	0.19	-0.12 (-1.63, 0.33)	0.19
uPDI				
tertile 1 (n = 54)	1	-	1	-
tertile 2 (n = 50)	0.10 (-0.37, 1.42)	0.24	1.28 (-0.33, 1.56)	0.20
tertile 3 (n = 54)	0.11 (-0.34, 1.41)	0.23	1.19 (-0.36, 1.50)	0.23

PDI: plant based dietary index; hPDI: healthy plant based dietary index; uPDI: unhealthy plant based dietary index

*The results were adjusted for age, sex, BMI, smoking, alcohol drinking, treatments, supplement use, and disease duration

cooking methods can affect the nutrient content of different plant foods, and these factors were not assessed in this study.

Conclusion

In conclusion, the results of this cross-sectional study showed that higher PDI was significantly associated with lower disease severity in patients with UC. From a clinical point of view, clinicians and diet therapists can recommend PBD for patients with UC. From the research point of view, considering the limitations of the study, more cohort studies with larger sample sizes are needed to confirm these results.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-024-03392-8.

Supplementary Material 1

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Author contributions
K.M.S: patient recruitment, Writing - review & editing; Z.N: Funding acquisition, Data curation, Formal analysis, Methodology, Writing - original draft; ZB: Investigation, patient recruitment, data collection, Writing - review & editing; RM: Conceptualization, Supervision,

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Data availability
The datasets supporting the conclusions of this research are included in the article.

Declarations

Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Committee of Tabriz University of Medical Sciences (Ethics code: IR.TBZMED.REC.1402.828). Written informed consent was obtained from all participants.

Consent for publication
None required.

Competing interests
The authors declare no competing interests.

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