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The Association Between a Mediterranean Diet and Symptoms of Irritable Bowel Syndrome

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Abstract

BACKGROUND & AIMS: Low adherence to Mediterranean diet (MD) has been shown to be associated with a higher prevalence of irritable bowel syndrome (IBS), but its association with IBS symptoms is not established. We aim to assess the association between MD and IBS symptoms, identify components of MD associated with IBS symptoms, and determine if a symptom-modified MD is associated with changes in the gut microbiome.

METHODS: One hundred and six Rome +IBS and 108 health control participants completed diet history and gastrointestinal symptom questionnaires. Adherence to MD was measured using

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Conflicts of interest

These authors disclose the following: Emeran Mayer is a scientific advisory board member of Danone, Axial Biotherapeutics, Amare, Mahana Therapeutics, Pendulum, Bloom Biosciences, Seed, and APC Microbiome Ireland. Lin Chang is consultant for Food Marble; and has stock options in Food Marble and ModifyHealth. The remaining authors disclose no conflicts.

CRediT Authorship Contributions

Ellie Ying Chen, MD (Conceptualization: Lead; Methodology: Equal; Visualization: Equal; Writing – original draft: Lead; Writing – review & editing: Lead)
Swapna Mahurkar-Joshi (Formal analysis: Lead; Methodology: Equal; Validation: Lead; Visualization: Equal; Writing – original draft: Supporting; Writing – review & editing: Supporting)
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Nancee Jaffe (Conceptualization: Supporting; Methodology: Equal; Writing – review & editing: Supporting)
Jennifer Labus (Formal analysis: Supporting; Funding acquisition: Equal; Methodology: Equal; Validation: Supporting; Writing – review & editing: Supporting)
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Lin Chang (Conceptualization: Lead; Methodology: Equal; Supervision: Lead; Writing – review & editing: Lead)

Supplementary Material

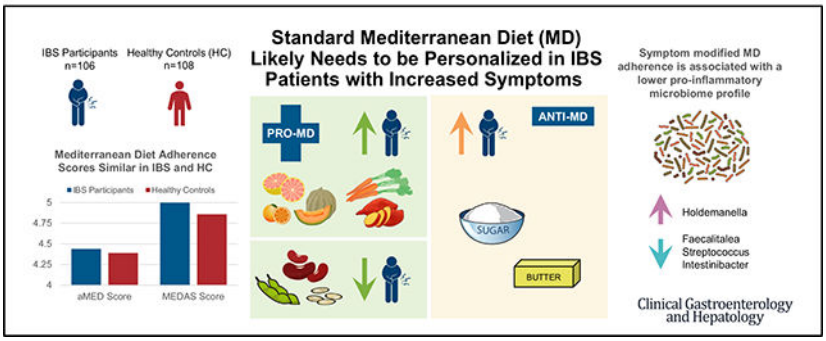
Note: To access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at https://doi.org/10.1016/j.cgh.2023.07.012.

Alternate Mediterranean Diet and Mediterranean Diet Adherence Screener. Sparse partial least squares analysis identified MD food items associated with IBS symptoms. Stool samples were collected for 16S ribosomal RNA gene sequencing and microbial composition analysis in IBS subjects.

RESULTS: Alternate Mediterranean Diet and Mediterranean Diet Adherence Screener scores were similar between IBS and health control subjects and did not correlate with Irritable Bowel Syndrome Severity Scoring System, abdominal pain, or bloating. Among IBS participants, a higher consumption of fruits, vegetables, sugar, and butter was associated with a greater severity of IBS symptoms. Multivariate analysis identified several MD foods to be associated with increased IBS symptoms. A higher adherence to symptom-modified MD was associated with a lower abundance of potentially harmful *Faecalitalea*, *Streptococcus*, and *Intestinibacter*, and higher abundance of potentially beneficial *Holdemanella* from the Firmicutes phylum.

CONCLUSIONS: A standard MD was not associated with IBS symptom severity, although certain MD foods were associated with increased IBS symptoms. Our study suggests that standard MD may not be suitable for all patients with IBS and likely needs to be personalized in those with increased symptoms.

Graphical Abstract



Keywords

Mediterranean Diet; Irritable Bowel Syndrome; Symptoms; Microbiome

Mediterranean-style diet (MD) is the traditional eating habits of people in countries bordering the Mediterranean Sea. It is considered a healthy lifestyle characterized by high intake of whole grains, fruits, vegetables, nuts, and seeds. Fish and other seafood, poultry, and dairy are eaten in moderation, and red meat and foods high in sugar are eaten on occasion. Olive oil is the main fat source in an MD.[1]

Growing evidence indicates that the consumption of the MD can reduce the risk of cardiovascular disease, diabetes, and cancer through the antioxidant-rich and anti-inflammatory properties of its essential foods.[2,3] There are several properties of the MD that may promote gut health. High amounts of phenols in the MD diet have been shown to have anti-inflammatory properties including decreased expression of inflammatory molecules.[4] In addition, MD is associated with increased abundance of short-chain fatty acid–producing microbiota, which help to maintain proper function of the intestinal

epithelium.[5] Furthermore, olive oil has been shown to be associated with decreased intestinal inflammation and visceral hypersensitivity in animal studies.[6,7]

Irritable bowel syndrome (IBS) is a common gastrointestinal (GI) condition affecting approximately 4%–11% of the global population.[8] The pathogenesis of IBS is multifactorial reflecting a combination of various host and environmental factors.[9] Not only does diet contribute to the pathogenesis of IBS, but most patients with IBS identify foods as a trigger to their IBS symptoms.[10] Dietary interventions, such as the low fermentable oligo-, di-, monosaccharides and polyols (FODMAP) diet are considered first-line treatments for IBS.[11] However, most dietary interventions focus on elimination of trigger foods and can be restrictive, difficult to maintain, may lead to deficiencies certain nutrients, and change intestinal microbiota negatively.[12,13] Therefore, more balanced dietary guidelines are needed for dietary management of IBS.

Although the MD is a well-balanced diet in contrast to more restrictive diets (eg, low FODMAP, gluten-free), few studies have examined the association between MD and IBS.[14–16] Limited data suggest that low adherence to an MD is associated with a higher prevalence of IBS and other disorders of gut-brain interaction, but the association between MD and IBS symptoms has not been well investigated. Furthermore, there are currently no studies on the contribution of individual MD foods to IBS symptoms to determine if certain components of the MD diet should be modified for patients with IBS.

The aims of our study are to (1) compare MD adherence in participants with IBS and healthy control subjects (HCs); (2) determine if MD correlates with severity of IBS symptoms, including abdominal pain, bloating, and overall IBS symptoms; (3) identify components of the MD that correlate with severity of IBS symptoms; and (4) determine if symptom-modified MD is associated with a difference in microbiome profile. We hypothesized that in general, adherence to the MD would not differ in IBS and HCs, but patients with IBS who had greater adherence to an MD would have decreased IBS symptom severity and a different fecal microbiome profile than patients with IBS who were less adherent to an MD. Additionally, we hypothesized that there may be some individual MD foods (eg, high FODMAP foods) that would be associated with greater IBS symptom severity.

Methods

Participants

This study was a cross-sectional study including retrospective analysis of adult participants with IBS and HCs who participated in IBS clinical research studies conducted between July 2013 and November 2021 at G. Oppenheimer Center for Neurobiology of Stress and Resilience at the University of California, Los Angeles.

The diagnosis of IBS was made using the Rome III or Rome IV[17,18] criteria depending on the time of recruitment. HCs had no history of GI symptoms or disease. Participants with organic GI diseases were excluded. Participants who submitted stool samples for microbiota analysis were also excluded if they received antibiotics within the previous 3 months.

Additional details regarding inclusion and exclusion criteria were published previously; however, assessment of MD adherence and its relationship to IBS symptoms are novel and not previously published.[13]

This study was approved by the University of California, Los Angeles institutional review board.

Irritable Bowel Syndrome Symptom-Related Questionnaires

IBS participants completed validated GI symptom-related questionnaires including Bowel Symptom Questionnaire[19] and Irritable Bowel Syndrome Severity Scoring System (IBS-SSS)[20] (Supplementary Methods).

Psychological Symptoms Assessment

Participants completed the validated questionnaires: Visceral Sensitivity Index (VSI),[21] which measures GI symptom-related anxiety; and Hospital Anxiety and Depression Scale,[22] which measures current anxiety or depression symptoms (Supplementary Methods).

Dietary Assessment

Dietary information was obtained through the Diet History Questionnaire II (DHQ II).[23] MD adherence was assessed by validated Alternate Mediterranean Diet (aMED) and Mediterranean Diet Adherence Screener (MEDAS) scores. aMED was an adaptation of the traditional MD to non-MD countries,[24] whereas MEDAS was used to guide the PREDIMED trial, one of the leading studies of the MD.[3] Alternative Healthy Eating Index-2010 was also calculated for each participant to assess for diet quality because it was designed to reduce chronic disease risks (Supplementary Tables 1–3).[25]

In addition, a GI dietitian identified DHQ II food groups and individual food items that were either consumed regularly or avoided/consumed occasionally (<1 serving a day) in an MD for further analysis based on a combination of Dietary Inflammatory Index and the scoring guide used in the PREDIMED study (Supplementary Table 4).[3,26] We termed these foods “pro-MD foods” and “anti-MD foods,” respectively. The average total daily consumption of these foods was calculated from the DHQ II data using the Diet*Calc software[27] and reported as grams per day.

Statistical Analysis

IBS versus HC group comparisons for demographic characteristics, MD adherence scores, and food items were performed using independent t-tests, general linear model, or chi-square tests. Generalized logistic regression (link logit) with IBS status as a dependent variable was used to determine the group differences adjusting for Hospital Anxiety and Depression Scale-Anxiety. General linear model was used to determine the association between IBS symptoms and MD adherence. Statistical significance was defined as $P < .05$. Sparse partial least squares regression implemented in mixOmics R package was applied to determine the relationships between dietary intake of anti-MD and pro-MD foods with IBS symptom severity measures (Supplementary Methods).

Based on the dietary variables selected by the model and their correlation with IBS symptoms, a symptom modified-aMED (aMED-m) score was calculated by omitting the pro-MD food items associated with increased IBS symptoms from the standard aMED calculations. We compared differences in gut microbiome in those with low, medium, and high aMED-m scores.

Microbiome Analysis

DNA was extracted from fresh frozen stool samples using the PowerSoil DNA Isolation Kit (MO BIO, Carlsbad, CA). The V4 hypervariable region was amplified using the 515F and 806R primer set. DNA was then purified using a commercial kit and the DNA was sequenced using an Illumina HiSeq 2500 (Illumina, San Diego, CA). The raw reads were then processed through DADA2 using default parameters to generate amplicon sequence variants. Taxonomic assignment was performed using the Silva 138 database. Low abundant amplicon sequence variants were removed if they did not have a relative abundance of greater than 1E-7. The mean reads per sample was 57,462 with a standard deviation of 25,423. Alpha diversity and beta diversity was calculated using QIIME 2. The distance metric used for beta diversity was the robust Aitchison from the DEICODE plugin in QIIME 2. Significance for beta diversity was calculated using the Adonis package in R, which uses permutational multivariate analysis of variance. Beta diversity was visualized using principal coordinate analysis plots. Alpha diversity was measured using a measurement of species evenness (Shannon Index) and richness (Chao1 index). Differential abundance testing was performed using DESeq2 in R, which uses a negative binomial modeling to test nonrarefied count data. *P* values were converted to q-values to correct for multiple hypothesis testing.

Results

IBS participants and HCs were similar in age, sex, body mass index, and race (Table 1). However, IBS participants had higher Hospital Anxiety and Depression Scale-Anxiety scores compared with HCs (7.94 vs 4.23; $P = 3.0e-11$) and were more likely to consume a restrictive diet than HCs (14% vs 4%; $P = 5.90e-05$).

There were no significant differences in mean aMED and MEDAS scores between IBS participants and HCs (M [standard deviation (SD)] 4.44 [1.82] vs 4.39 [1.80], $P = .83$; and 5.0 [1.37] vs 4.86 [1.40], $P = .46$). There were also no significant associations between adherence to MD and overall IBS symptoms, abdominal pain, bloating, VSI, and IBS-SSS (Table 2). In terms of diet quality, aMED and MEDAS scores were positively associated with Alternative Healthy Eating Index scores ($r = 0.54$, t[dof] = 9.40 [212], $P < 2.2e-16$; and $r = 0.45$, t[dof] = 7.26 [212], $P = 7.19e-12$, respectively). Overall, 21% of IBS participants and 9% HCs were of Mediterranean descent ($P = .18$). However, the aMED and MEDAS scores were not different between our participants of Mediterranean descent countries compared with those with any other country of origin (M [standard deviation (SD)] 4.36 [1.78] vs 4.35 [1.89], $P = .98$; and 4.87 [1.39] vs 5.13 [1.41], $P = .35$).

For pro-MD and anti-MD food groups, IBS participants, on average, consumed less beans compared with HCs ($P = .048$) (Table 3). Furthermore, in IBS participants, fruits were associated with higher abdominal pain, bloating, and IBS-SSS; and vegetables were

associated with higher VSI scores (all $P < .05$). However, higher consumption of beans, legumes, and soy (pro-MD) was associated with lower overall symptoms and IBS-SSS ($P = .0004$ and .002, respectively) but not with VSI. Higher consumption of anti-MD food groups, such as added sugar, was associated with higher abdominal pain ratings; and higher consumption of butter, creams, and margarine was associated with higher bloating and IBS-SSS scores (all $P < .05$) (Table 4).

The sparse partial least squares model identified pro-MD and anti-MD foods most associated with IBS symptoms to create a single dietary signature. Supplementary Figure 1 shows the loadings of the variables selected by the model. There was a negative correlation between overall dietary signatures scores and IBS symptoms (eg, dietary signature vs IBS-SSS, $r = -0.46$, $P = .0001$). Increased consumption of some anti-MD foods (eg, soda, processed meat, baked goods, and beer) was most associated with less IBS symptoms, whereas increased consumption of some pro-MD foods (eg, cantaloupe, carrot juice, grapefruit, sweet potato, and oranges/tangerines/clementines) was most associated with more IBS symptoms (Figure 1).

Our study showed that there was no difference in beta diversity between subjects with high, medium, and low aMED-m scores. However, a higher aMED-m score was associated (q-value <0.05) with lower abundance of *Faecalitalea*, *Streptococcus*, and *Intestinibacter*, and higher abundance of *Holdemanella* from the Firmicutes phylum (Figure 2).

Discussion

Our study showed that there was no difference in adherence to the MD between IBS participants and HCs. In addition, although MD was associated with higher diet quality, we did not find correlations between MD adherence and IBS symptoms. However, when the MD was further analyzed by its main food groups, we found that a higher intake of certain pro-MD and anti-MD foods was associated with greater severity of IBS symptoms. Interestingly, multivariate analysis of individual food items showed that higher consumption of several pro-MD foods, such as cantaloupe, was associated with higher IBS symptoms, whereas higher consumption of several anti-MD foods, such as soda, was associated with lower IBS symptom severity.

Previous studies showed an inverse relationship between adherence to the MD and prevalence of IBS. Zito et al[14] surveyed 1134 participants in Southern Italy and found an association between lower adherence to MD and higher prevalence of IBS and functional dyspepsia in younger participants ($P < .05$). The authors concluded that low adherence to the MD may be a risk factor for development of disorders of gut-brain interaction in this population.[14] Similarly, Agakidis et al[15] studied 1116 children in Greece and found that good adherence to MD was associated with lower prevalence of disorders of gut-brain interaction, such as functional constipation, IBS, and functional dyspepsia according to the Rome III criteria ($P = .001$). In contrast, our study did not show a difference in MD adherence between IBS and HCs. This may be caused by differences in the study populations and standard diets. Furthermore, Agakidis et al[15] studied children from age 6–18 and the study by Zito et al[14] only showed significant association between MD adherence

and IBS in the younger age group, whereas our study included only adults and was not stratified by age. It is possible that IBS participants in these studies consumed less MD foods that aggravated their symptoms; however, the association between MD adherence and GI symptoms was not assessed in these studies.

More recently in 2021, Altomare et al[16] conducted a pilot study in Rome, Italy where dietary habits, IBS symptoms, and gut microbiome were compared between 28 IBS participants and 21 HCs. This study found that IBS participants had lower MD adherence score compared with HCs. There was no association between MD adherence and IBS symptoms of abdominal pain and flatulence. Specific microbial biomarkers were detected for altered and adequate nutrient intake in patients with IBS. These results agreed with our findings that MD adherence was not associated with IBS symptoms. However, this was a much smaller study with only 28 IBS participants compared with our larger study.

Previous studies have shown that adherence to the MD is associated with positive changes to the gut microbiome.[5] Similarly, our study showed that IBS subjects who were adherent to a symptom-modified MD were associated with a lower abundance of potentially proinflammatory, pathogenic, and gas-producing microbes, such as *Faecalitalea*, *Intestinibacter*, and *Streptococcus*,[28–30] and a higher abundance of anti-inflammatory *Holdemanella*[31] from the Firmicutes phylum. These preliminary findings suggest that symptom-modified MD may be associated with beneficial changes to the microbiome. However, future studies should assess microbial function because 16S rRNA analysis measures microbial composition but not function.

Despite being a healthy diet, the MD has not been shown to be beneficial for IBS symptom severity in our study and the literature. Prior studies on dietary management of IBS show that the low FODMAP diet and the National Institute for Health and Care Excellence traditional diet for IBS are effective in reducing IBS symptoms,[11,32] which recommend limited intake of FODMAPs, high-fiber foods, resistant starches, and fruits. In contrast, the main components of the MD include fruits, vegetables, whole grains, and legumes, many of which have been shown to be associated with increased IBS symptoms in our study. The pro-MD foods identified to increase IBS symptoms are also associated with higher quantities of FODMAPs. Therefore, these components of a standard MD are not considered to be a part of an IBS-friendly diet and should be reduced to a quantity that can be tolerated for those with more severe IBS symptoms. Similarly, individuals may have different food triggers, thus a generalized MD may not be suitable for all patients with IBS or needs to be personalized as with a low FODMAP diet.

In our study, IBS participants consumed less beans/legumes/soy compared with HCs likely because these foods can trigger GI symptoms. In IBS, the higher consumption of beans/legumes/soy was associated with lower IBS symptom severity but not GI symptom-related anxiety. It is possible that beans/legumes/soy were preferentially avoided in IBS participants with more severe symptoms and consumed more in those with relatively lower visceral sensitivity or less gas-producing gut microbiome. However, they do not seem to be reducing their consumption of beans/legumes/soy because of worries or fears related to IBS symptoms. Additionally, several anti-MD foods were also associated with less IBS

symptoms. We previously showed that patients with IBS with more severe IBS symptoms consumed a more restrictive diet.[13] Thus, our findings might simply demonstrate that those with milder IBS can tolerate a greater variety of foods.

There were strengths that differentiated our study from prior studies. It is one of the largest studies to date that examined the association between MD intake and IBS symptoms with 106 IBS participants and 108 HCs. Our study included all IBS bowel habit subtypes and controlled for covariates including age, race, and Hospital Anxiety and Depression Scale-Anxiety. We used validated MD adherence scores and performed a detailed dietary assessment of the MD including individual pro-MD and anti-MD food groups and food items. Moreover, IBS symptoms were assessed using multiple validated instruments.

There were several limitations. This study was a cross-sectional study; therefore, patients were not randomized into specific dietary interventions and the results only demonstrated association but not causation. In addition, diet was assessed with DHQ II, which relied on diet recall in the past year instead of multiple time points and did not capture lifestyle components of the MD. Furthermore, the population of this study was based in Los Angeles, which resulted in lower average MD scores compared with the Mediterranean populations. In addition, our population also consumed significantly less olive oil compared with MD studies (average of 3g vs 55g[3]). To bridge this gap, our study also included aMED score, which was developed to assess MD intake in non-Mediterranean countries and accounted for differences in dietary patterns in different populations. However, our population may still be consuming a different MD than those in Mediterranean countries.

In summary, our study showed that although a standard MD was a healthy diet, adherence to the MD was not higher in IBS participants compared with HCs, nor was it associated with less severe IBS symptoms. Certain pro-MD foods were associated with increased symptoms, possibly because of high FODMAP content. Patients with milder IBS symptoms may be more liberal with their diet, whereas those with more severe symptoms may need to restrict certain anti-MD foods to lessen symptoms. Our findings suggest that an IBS-modified MD, rather than a standard MD, should be considered to reduce IBS symptom severity in research studies and clinical practice.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations used in this paper:

aMED	alternate Mediterranean diet
aMED-m	symptom modified-aMED
DHQ II	Diet History Questionnaire II
FODMAP	fermentable oligo-, di-, monosaccharides and polyols
GI	gastrointestinal
HC	healthy control subjects
IBS	irritable bowel syndrome
IBS-SSS	Irritable Bowel Syndrome Severity Scoring System
MD	Mediterranean diet
MEDAS	Mediterranean Diet Adherence Screener
VSI	Visceral Sensitivity Index

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What You Need to Know

Background

The Mediterranean diet is considered to be a healthy diet. Although few studies show that Mediterranean diet adherence is inversely associated with incidence of IBS, the association between Mediterranean diet and IBS symptoms is not well established.

Findings

Adherence to the Mediterranean diet was not associated with severity of IBS symptoms. In addition, food groups such as fruits and vegetables were associated with increased IBS symptoms. Symptom modified Mediterranean diet was associated with more beneficial gut microbiome profile.

Implications for patient care

An IBS-modified Mediterranean diet, rather than a standard Mediterranean diet, should be considered for the management of IBS symptoms.

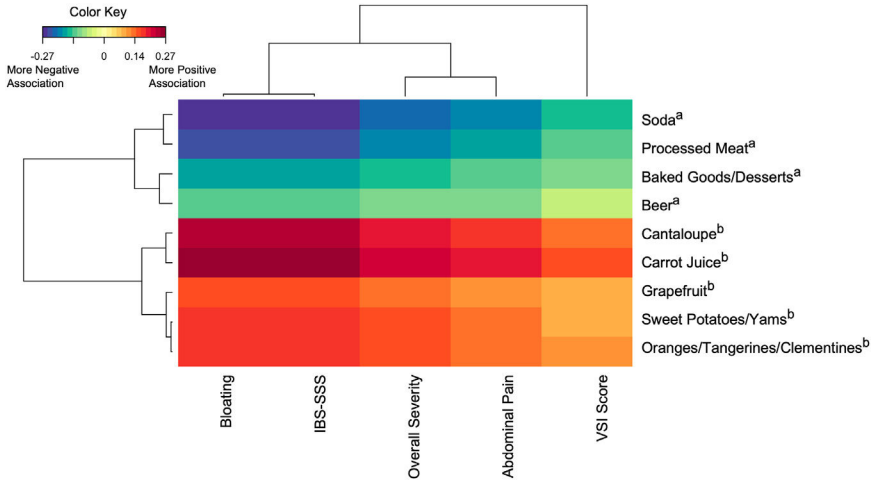

Figure 1.

Sparse partial least squares analysis of the correlations between MD food items and IBS symptoms. Anti-MD foods are foods typically avoided or consumed occasionally in a Mediterranean style diet. Pro-MD foods are foods preferentially consumed in a Mediterranean-style diet. The heatmap shows Pearson correlation coefficients between the derived dietary variables and derived symptom variables. *Deeper red* color represents higher positive correlation and *deeper blue* represents higher negative correlation. Dendrogram row/column clusters based on the hierarchical clustering method. [a]Anti-MD foods. [b]Pro-MD foods.

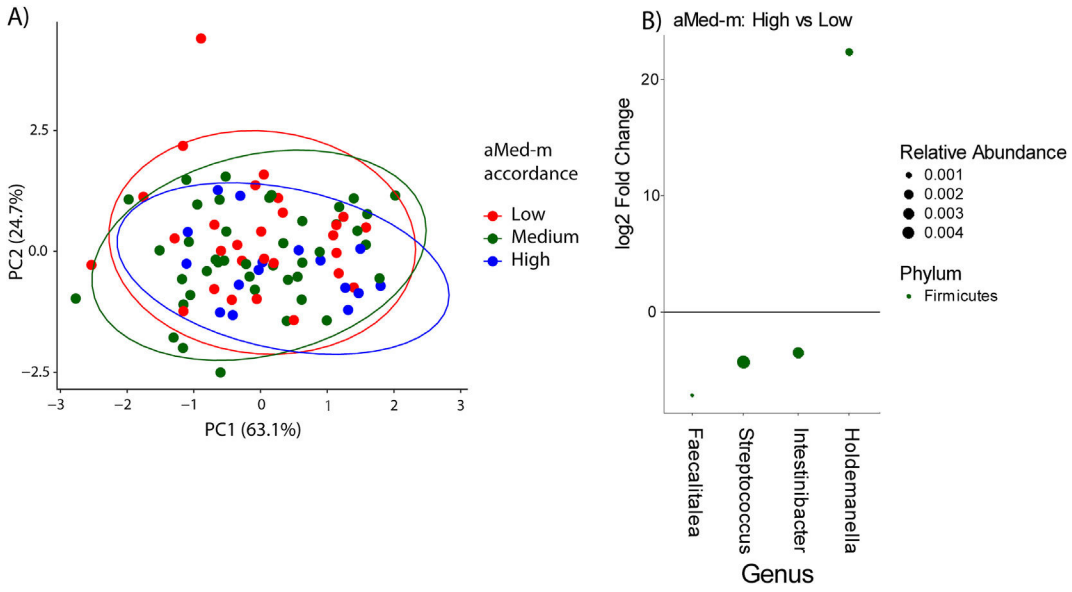

Figure 2.

(*A*) Principal coordinate analysis comparison in beta-diversity between IBS subjects with low, medium, and high symptom aMED-m. (*B*) Relative abundance of fecal microbiota in IBS subjects with high aMED-m versus low aMED-m score.

Table 1.

Demographic Characteristics

	IBS (N = 106)	HCS (N = 108)	*P* VALUE
Age	28.75 (10.93)	28.85 (10.43)	.95
Sex, n (%)	77 (73)	84 (78)	.43
BMI	23.88 (4.03)	24.73 (3.59)	.1
HADS-Anxiety	7.94 (4.24)	4.23 (3.41)	3.0e-11
Race, n (%)			.61
Asian	26 (24)	38 (35)	
Black	7 (6)	9 (8)	
White	56 (53)	42 (39)	
Multiracial	10 (9)	11 (10)	
Not available	7 (7)	8 (7)	
Hispanic, n (%)	26 (24)	22 (20)	.34
aMED score	4.44 (1.82)	4.39 (1.80)	.83
MEDAS score	5.0 (1.37)	4.86 (1.40)	.46
Restrictive diet[a]	30 (14)	8 (4)	5.90e-05
Bowel habit subtype, n (%)			
IBS-C	30 (28)		
IBS-D	41 (39)		
IBS-M	10 (9)		
IBS-U	25 (23)		
Overall severity (0–20)	10.11 (4.12)		
Abdominal pain (0–20)	8.94 (4.33)		
Bloating (0–20)	11.39 (5)		
VSI score (0–75)	39.69 (15.04)		
IBS-SSS (0–500)	248.91 (81.44)		

aMED, alternate Mediterranean index; BMI, body mass index; HADS, Hospital Anxiety and Depression Scale; HCs, healthy control subjects; IBS, irritable bowel syndrome; IBS-C, constipation-predominant IBS; IBS-D, diarrhea-predominant IBS; IBS-M, IBS with mixed bowel habits; IBS-U, IBS unclassified; IBS-SSS, Irritable Bowel Syndrome Severity Scoring System; MEDAS, Mediterranean Diet Adherence Score; VSI, Visceral Sensitivity Index.

[a]Gluten-free, dairy-free, and/or low FODMAP diets.

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Table 2.

Correlation Between MD Adherence and IBS Symptoms

	aMED Scores			MEDAS Scores		
	Estimate	**Standard error**	***P* value**	**Estimate**	**Standard error**	***P* value**
Overall symptoms	−0.08	0.24	.74	−0.12	0.32	.71
Abdominal pain	−0.03	0.25	.92	−0.39	0.33	.24
Bloating	0.37	0.28	.19	0.61	0.37	.10
VSI score	1.49	0.83	.08	1.17	1.05	.29
IBS-SSS	2.70	4.70	.57	3.06	6.17	.62

NOTE. The values were generated using linear regression covarying for body mass index, race, and Hospital Anxiety and Depression Scale-Anxiety. The estimates are beta values from the linear regression model.

aMED, alternate Mediterranean index; IBS, irritable bowel syndrome; IBS-SSS, Irritable Bowel Syndrome Severity Scoring System; MD, Mediterranean diet; MEDAS, Mediterranean Diet Adherence Score; VSI, Visceral Sensitivity Index.

Table 3.

Differences in Consumption of Pro-Mediterranean and Anti-Mediterranean Food Groups Between IBS and HCs[a]

	IBS (N = 106)	HCs (N = 108)	Estimate	Standard error	FDR *P* value
Pro-MD **f**oods, *g/d* (SD)					
Beans/legumes/soy	30.18 (63.88)	37.89 (69.34)	−0.015	0.005	.048
Fish/seafood	24.37 (32.41)	31.86 (52.93)	−0.012	0.005	.12
Fruit	262.8 (278.14)	263.9 (313.92)	−2.6e-04	0.001	.70
Grains (whole)	102.74 (105.86)	104.8 (124.56)	8.4e-05	0.001	.95
Nut/seeds	19.59 (30.46)	19.21 (24.75)	−0.003	0.006	.70
Olive oil	3 (3.1)	3.57 (4.37)	−0.08	0.051	.26
Poultry	49.77 (62.8)	48.24 (70.33)	−0.004	0.003	.32
Vegetables	248.37 (256.15)	308.95 (417.42)	−0.001	0.001	.12
Water	2350.04 (2603.21)	2329.08 (2749.07)	−7.5e-05	6.5e-05	.39
Wine	21.81 (30.53)	25.05 (36.96)	−0.007	0.006	.39
Anti-MD **f**oods, *g/d* (SD)					
Added sugar	253.86 (590.78)	269.28 (806.63)	−0.0002	0.0002	.98
Alcohol (not wine)	105.93 (225.17)	68.12 (110.58)	0.001	0.001	.64
Baked goods/dessert/sweets	26.73 (34.07)	43.96 (88.02)	−0.008	0.004	.64
Butter, margarine, cream	23.58 (68.92)	18.62 (35.99)	−0.004	0.004	.92
Fried food	19.29 (21.47)	25.28 (42.51)	−0.01	0.006	.64
Red/processe**d** meat	54.25 (69.84)	80.68 (148.31)	−0.003	0.002	.64

NOTE. The values were generated using generalized linear model (link=logit) covarying for body mass index, race, and Hospital Anxiety and Depression Scale-Anxiety. The estimates are beta values from the model.

FDR, false discovery rate; HCs, healthy control subjects; IBS, irritable bowel syndrome; MD, Mediterranean diet; SD, standard deviation.

[a]Consumption is measured in average total grams/day consumed per subject (SD).

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Table 4.

Correlation Between Mediterranean Food Intake and IBS Symptoms

	Overall symptoms		Abdominal pain		Bloating		VSI		IBS-SSS	
Pro-MD foods	**Estimate**	***P* value**	**Estimate**	***P* value**	**Estimate**	***P* value**	**Estimate**	***P* value**	**Estimate**	***P* value**
Beans/legume/soy	−0.05	.0004	−0.023	.12	−0.018	.29	−0.061	.21	−0.941	.002
Fish/seafood	0.011	.47	0.022	.17	0.015	.43	0.093	.08	0.335	.28
Fruit	0.003	.10	0.004	.009	0.006	.004	0.007	.17	0.101	.0005
Grains (whole)	−0.003	.51	−0.001	.87	−0.007	.16	0.016	.25	−0.1	.20
Nut/seeds	−0.001	.95	0.003	.83	0.006	.75	−0.019	.72	0.115	.69
Olive oil	0.129	.39	0.183	.23	0.235	.18	0.051	.92	3.054	.27
Poultry	0.001	.85	0.003	.71	0.001	.88	0.014	.57	−0.006	.97
Vegetables	0.001	.48	0	.82	0.004	.072	0.013	.027	0.045	.18
Water	0	.74	0	.71	0	.40	0	.92	0.003	.36
Wine	0.012	.51	−0.006	.76	0.001	.48	0.076	.21	0.381	.22
Anti-MD foods										
Added sugar	0.001	.14	0.003	.006	0.001	.48	0.004	.21	0.033	.08
Alcohol (not wine)	−0.001	.67	0	.92	−0.004	.13	−0.013	.07	−0.066	.09
Baked goods/dessert/sweets	0.004	.78	0	.98	−0.017	.25	0.052	.24	−0.137	.58
Butter/margarine/cream	0.01	.25	0.005	.54	0.021	.03	0.041	.12	0.346	.02
Fried food	0.015	.45	0.011	.62	−0.013	.58	0.014	.84	0.012	.98
Red meat/processed meat	−0.001	.88	0.008	.23	−0.004	.66	0.012	.58	−0.103	.44

NOTE. This table shows the associations between Mediterranean food item intake and IBS symptom severity measures and the estimates represents the regression beta values generated using linear regression covarying for body mass index, race, and Hospital Anxiety and Depression Scale-Anxiety.

IBS, irritable bowel syndrome; IBS-SSS, Irritable Bowel Syndrome Severity Scoring System; MD, Mediterranean diet; VSI, Visceral Sensitivity Index.