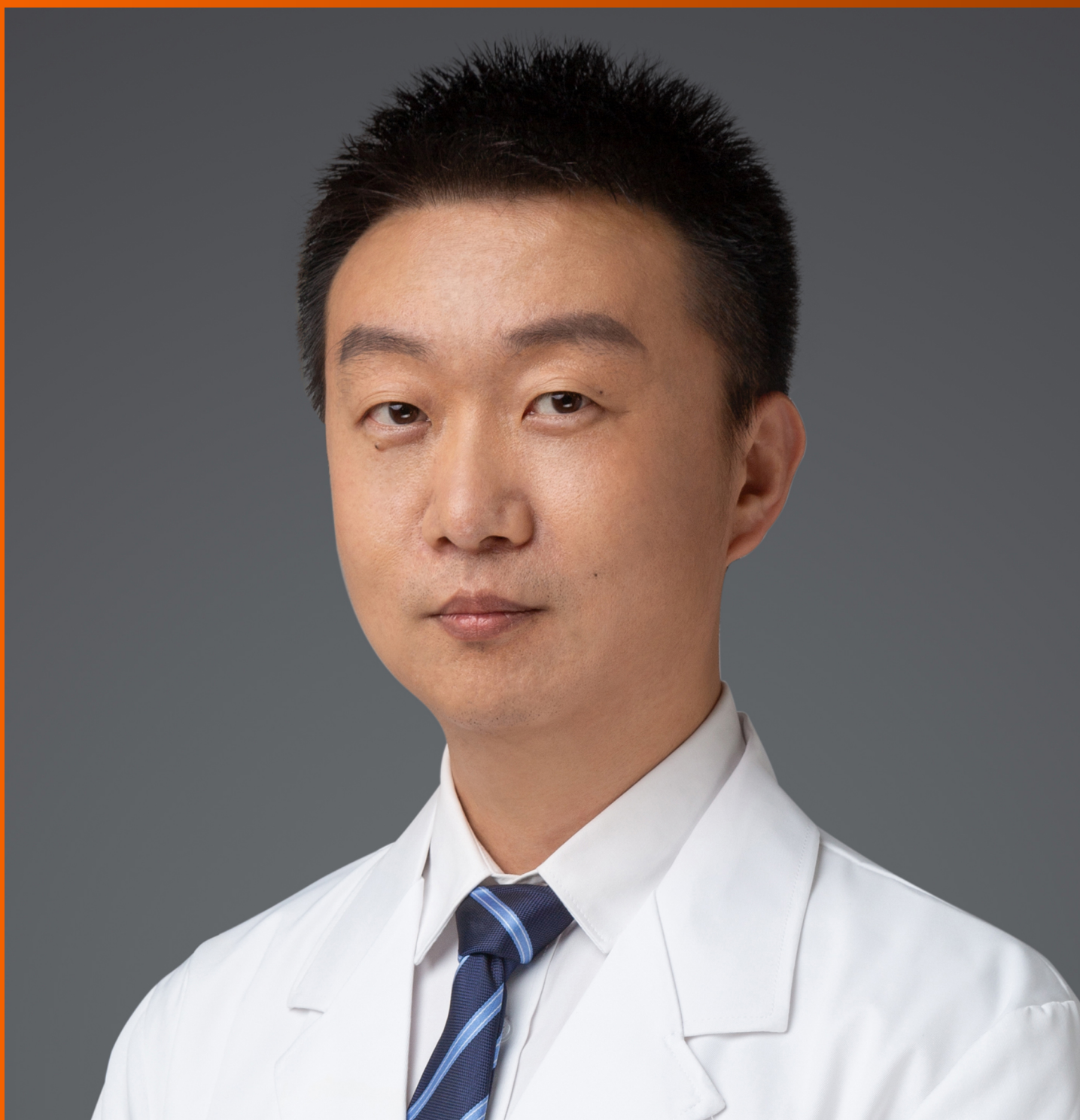


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Observational Study

Differences in dietary habits of people with vs without irritable bowel syndrome and their association with symptom and psychological status: A pilot study

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Abstract

BACKGROUND

Previous studies have demonstrated that dietary factors are involved in irritable bowel syndrome (IBS), but the role of diet was evaluated mostly based on food frequency questionnaire. Whether food categories, quantity per time, and intake frequency are different between IBS patients and non-IBS individuals has not been clearly clarified.

AIM

To explore differences in dietary habits of people with vs without IBS and their correlation with symptom and psychological status.

METHODS

A total of 220 questionnaires were administered in a community population and the Rome IV criteria was applied to diagnose IBS. The dietary questionnaire used in this study was multidimensional from food categories, quantity per time, and intake frequency, in contrast to “yes or no” classification used in previous studies. Questionnaires including IBS symptom severity scale (IBS-SSS), IBS quality of life, visceral sensitivity index, hospital anxiety and depression score (HADS), and gastrointestinal symptom rating scale were used to assess the participants. Rank sum test was used to compare the quantity per time and intake frequency between IBS patients and non-IBS participants. The correlation between psychological factors and diet was evaluated by Spearman correlation analysis. Logistic

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regression analysis was used to assess the possible dietary risk factors for IBS.

RESULTS

In total, 203 valid questionnaires were collected (response rate 92.3%). Twenty-five participants met the Rome IV criteria for IBS, including 15 (60.0%) women and 10 (40.0%) men. Compared with the non-IBS group, the quantity per time and intake frequency of soybean and its products, spicy food, and dry-fried nuts were statistically significant in IBS participants ($P < 0.05$). They were positively associated with IBS-SSS and HADS anxiety and depression scores ($P < 0.05$). Besides, seafood, soft drinks, vegetables, and fruits differed only in quantity per time. The intake frequencies of egg, barbecue, and coarse grain were statistically significant in IBS patients ($P < 0.05$). We also found that the frequency of soybean and its products (≥ 7 times/week, odds ratio = 11.613, 95% confidence interval: 2.145-62.855, $P = 0.004$) was an independent risk factor for IBS.

CONCLUSION

Both quantity per time and intake frequency, especially soybean, differ between IBS patients and non-IBS participants. Dietary habits might play potential roles in the pathophysiology of IBS.

Key Words: Irritable bowel syndrome; Dietary habits; Quantity per time; Intake frequency; Symptom severity; Psychosocial status

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Core Tip: This study investigated the dietary habits between irritable bowel syndrome (IBS) patients and non-IBS participants based on a multidimensional questionnaire. We found that quantity per time and intake frequency of some foods were positively associated with symptom and psychological status, especially soybean. The intake frequency of soybean and its products was an independent risk factor for IBS.

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INTRODUCTION

Irritable bowel syndrome (IBS) is one of the most common functional bowel disorders characterized by abdominal pain and accompanied by changes in defecation habits and fecal traits, of which diarrhea-predominant irritable bowel syndrome (IBS-D) accounts for the majority of cases^[1,2]. According to the published literature, the prevalence of IBS varies from 0.2% to 29.2%^[2], and this variation might be related to research subjects, investigation methods, and diagnostic criteria^[3,4]. Recurrent symptoms led to a significant decline in the quality of life of patients, which was associated with substantial costs to patients, healthcare systems, and society. Effective interventions could alleviate the symptoms and improve the quality of life in IBS patients^[5].

The etiology and pathogenesis of IBS have not been fully elucidated but are considered to be the result of multiple factors, such as visceral hypersensitivity, intestinal mucosal inflammation, and increased intestinal permeability^[6]. Many studies have found that an inappropriate diet could induce or aggravate IBS symptoms, such as spicy food, fruit, soybeans, dairy products, onion, and meat^[7,8]. Recent studies suggested that the fermented oligosaccharide, disaccharide, monosaccharide, and polyol (FODMAP) diet and a gluten-rich diet played important roles in the pathogenesis of IBS^[9,10]. The effectiveness of low FODMAP diet and gluten-free diet (GFD) in alleviating IBS symptoms has been confirmed in many studies conducted in Western countries^[11-16].

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It has been known that dietary pattern, as a factor of nutrition, was different between the Eastern and Western countries. An Asian diet was characterized by high-carbohydrate, high-fiber, low-fat, and low-meat protein. A traditional Asian diet usually includes rice and vegetables, which are the main sources of carbohydrates and fibers. Vegetable oil is a common source of fat, while fish, egg, poultry, and pork are the major protein sources. This is different from a modern Western diet, which is rich in animal fat and protein, but low in carbohydrates and fibers^[17]. It is of great significance to fully understand the dietary habits in the Chinese population, for guiding the choice of diet therapy.

There has been no high-quality evidence to support the effectiveness of "elimination diet" in patients with IBS in China. In clinical practice, we found that the pathogenicity of diet might also be associated with quantity per time. However, the majority of studies using the food frequency questionnaire (FFQ)^[18-21] might not fully reflect the diet habits of IBS patients. Differing from FFQ^[22], although commonly used, we supposed that the effect of diet was similar to the dose-response and time-response relationship of drugs. Consequently, we designed and used a multidimensional dietary questionnaire. The innovative questionnaire involved three dimensions, including food categories, intake frequency, and quantity per time, rather than simply classifying responses as "yes or no" as noted in previous studies. Based on this innovative questionnaire, we surveyed the diet of residents in a Northern city of China, including IBS patients and non-IBS participants. We evaluated and analyzed the dietary habits between IBS patients and non-IBS participants objectively and semi-quantitatively according to the questionnaire. It helped to understand the dietary habits of IBS patients comprehensively, and to provide evidence for dietary guidance.

The main aim of this study was to compare dietary habits between IBS patients and non-IBS participants from food categories, quantity per time, and intake frequency in a Chinese population. The secondary purpose was to explore the correlation between symptom and psychological status and diet.

MATERIALS AND METHODS

Study setting

From May 2020 to July 2020, a cross-sectional survey was conducted among the permanent residents selected by simple random sampling in Hongsheng community in Gaomi City, Shandong Province, China. To some extent, they were representative of city residents in northern China. Finally, 220 residents were included in this study. The study was performed by filling in the questionnaires face to face. All participants were fully informed of the study and provided written informed consent. The study protocol was approved by the Ethics Committee of China-Japan Friendship Hospital (No. 2015-33), and the study was performed in accordance with the Declaration of Helsinki.

Study population

The inclusion criteria for participants were as follows: (1) Participants older than 18 years old, regardless of gender; and (2) There were no abnormalities during colonoscopy within half a year. Participants with the following conditions were excluded: (1) Presence of warning symptoms, such as hematochezia, positive fecal occult blood test, anemia, abdominal mass, ascites, fever, weight loss, and family history of colorectal cancer; (2) Family history of cancer; (3) Chronic diseases, such as diabetes mellitus, hypertension, chronic kidney disease, chronic hepatitis, liver cirrhosis, inflammatory bowel disease, and autoimmune diseases; (4) Abdominal and pelvic surgery; and (5) Pregnant or lactating women.

Criteria for IBS patients

The newest diagnostic criteria, Rome IV, were established in 2016^[23]. Recurrent abdominal pain occurred at a frequency of at least one day/week, associated with two or more of the following criteria: (1) Related to defecation; (2) Associated with a change in frequency of stool; or (3) Associated with a change in form (appearance) of stool. The criteria were fulfilled for the last 3 mo with symptom onset $\geq$ 6 mo before diagnosis. There were no morphological changes or biochemical abnormalities that could explain the symptoms.

Sociodemographic characteristics

Detailed baseline information, including age, gender, body mass index, level of education, drinking, and smoking, was obtained for each participant.

Dietary assessment

The dietary habits of 220 participants three to six months before investigation were assessed. The diet questionnaire was conducted by a trained researcher at the beginning of the study to interview each participant directly, and the mean time required to answer dietary questionnaire was approximately 15 min. Two hundred and three questionnaires were collected, of which 135 were valid (IBS patients 25, non-IBS participants 110).

There is no consensus among the studies on whether it is necessary to set the option "quantity per time" in the questionnaire. Researchers from the University of California believed that the option "quantity per time" could increase the validity of the FFQ^[24], while scholars from the Institute of Cancer Epidemiology in Copenhagen thought that it has little effect on the validity of the FFQ^[25]. In order to reflect the dietary habits of the participants in detail, we revised the FFQ according to the Chinese eating habits, and average quantity per time was included in the questionnaire. Thus, the diet questionnaire in this study included three elements: Food categories, quantity per time, and intake frequency.

Food list included six food categories: (1) Animal protein; (2) Vegetable protein; (3) Spicy food, barbecue, and dry-fried nuts; (4) Soft drinks; (5) Staple food, and (6) Vegetables and fruits. The pictures of each food in 25 g were presented to all participants for semi-quantitative estimation. We asked the participants to describe how many portions they ate each time, and counted the quantity per time. Product labels were used as appropriate. For soft drinks, soybean milk, and eggs, we took the bottles or numbers as the unit. The intake frequency (time/week [t/wk]) was divided into three groups: ≤ 1 t/wk, 2-6 t/wk and ≥ 7 t/wk, rather than "seldom, sometimes, and always" mentioned by FFQ^[26]. The detailed dietary questionnaire is provided in [Supplementary Table 1](#). The questionnaire focused not only on intake frequency, but also on quantity per time. Compared with FFQ, the dietary questionnaire revealed the eating habits with a wider range, while the validity of the questionnaire should be confirmed in a larger sample.

Questionnaires

Chinese version of Rome IV questionnaire: The diagnostic questionnaire used in this study is the Rome IV diagnostic questionnaire for adults^[27].

IBS symptom severity scale: This scale^[28] was used to assess the severity of IBS symptoms. The scale includes five items (abdominal pain degree, abdominal pain frequency, abdominal distension, stool characteristics, and quality of life). The score of each item is between 0 and 100, and the total score of the five items is calculated.

IBS-specific quality of life questionnaire: This scale^[29] was used to evaluate the quality of life of IBS patients and includes 34 items. The higher the score, the better the quality of life of patients.

Gastrointestinal symptom rating scale: The gastrointestinal symptoms were evaluated using a standardized gastrointestinal symptom rating scale (GSRS)^[30], and the common gastrointestinal symptoms were quantified. The specific items include heartburn, acid regurgitation, upper abdominal tightness, nausea and vomiting, bowel sounds, belching, increased frequency of defecation, feeling of urgency, and incomplete defecation. The score for each item is 0 to 3, and the total score is 0 to 30.

Visceral sensitivity index: The scale is a self-rating scale for assessing visceral sensitivity and anxiety related to gastrointestinal symptoms. The scale consists of 15 items. Each item is scored 1 to 5, and the scale has a total score of 0 to 75. The higher the score, the higher the visceral sensitivity and the more serious the anxiety.

Hospital anxiety and depression scale: Standardized hospital anxiety and depression scale (HADS)^[31] was used to assess the psychological state. The scale includes 14 items (7 items for anxiety and 7 items for depression), and each item is scored from 0 to 3 points. The HADS anxiety score and depression score were obtained by adding the individual item scores, separately.

Statistical analysis

SPSS version 26.0 (SPSS Inc., Chicago, IL, United States) was used for statistical analyses. The quantitative data are represented by the median (Q1, Q3) and the qualitative data are expressed as numbers (percentages). Wilcoxon rank sum test was used for comparison between groups. Spearman correlation analysis was used to evaluate the correlation between variables. Logistic regression analysis was used to assess the possible risk factors for IBS. $P < 0.05$ was defined as statistically significant. Statistical charts were generated using Graph Prism version 8.0 (GraphPad Software Inc., La Jolla, CA, United States).

RESULTS

Basic characteristics

The questionnaire was completed by 203 of the 220 participants (response rate 92.3%), including 122 (60.1%) women and 81 (39.9%) men. According to the Rome IV questionnaire, 25 participants were diagnosed with IBS, of whom 60.0% were women. The numbers of patients with IBS with predominant constipation, IBS-D, IBS with mixed bowel habits, and IBS unclassified were 5 (20%), 7 (28%), 9 (36%), and 4 (16%), respectively. Sociodemographic and clinical characteristics of IBS patients and non-IBS participants are presented in [Table 1](#).

Dietary habits

Sixty-eight questionnaires were incomplete. Only 135 (61.4%) dietary questionnaires were valid, including 25 IBS patients and 110 non-IBS participants. The dietary results were provided in the form of quantity per time ([Figure 1](#) and [2](#)) and intake frequency ([Figure 3](#) and [4](#)). The dietary factors of the two groups were evaluated comprehensively. We found that patients with IBS consumed more soybean and its products, spicy food, and dry-fried nuts in terms of quantity per time and intake frequency. Besides, seafood, soft drinks, vegetables, and fruits differed only in quantity per time. The intake frequencies of egg, barbecue, and coarse grain were statistically different. Results with significant differences are shown in [Table 2](#) and a more detailed analysis of dietary factors is provided in [Supplementary Table 2](#).

Symptom severity and psychological factors

We found that visceral sensitivity index [median (Q1, Q3): 64.0 (53.0, 68.5) *vs* 29.0 (17.5, 38.25), $P < 0.001$], HADS anxiety score [7.0 (3.5, 10.0) *vs* 3.0 (1.0, 6.0), $P < 0.001$], HADS depression score [5.0 (2.5, 8.0) *vs* 3.0 (1.0, 6.0), $P = 0.026$], and GSRS [4.0 (3.0, 6.5) *vs* 3.0 (1.0, 5.0), $P = 0.007$] were significantly increased in IBS patients compared with the non-IBS group. The relevant statistical data are shown in [Table 2](#).

Association between dietary factors and clinical score and psychological score

The univariate analysis demonstrated that the quantity per time and intake frequency of soybean and its products, spicy food, and dry-fried nuts were statistically significant. They were positively associated with IBS symptom severity scale (IBS-SSS), HADS anxiety score, and HADS depression score. The details are shown in [Table 3](#).

Risk factors for IBS

Combined with the previous literature, we finally entered the frequency of soybean and its products, spicy food and dry-fried nuts into multivariable logistic regression analysis, which demonstrated that the frequency of intake of soybean and its products (≥ 7 t/wk, odds ratio 11.613, 95% confidence interval 2.145–62.855, $P = 0.004$) was an independent risk factor for IBS. The results are shown in [Table 4](#).

DISCUSSION

IBS is a common functional bowel disorder that is the result of multiple factors. The role of diet in the occurrence and development of IBS has been widely studied. Diet could cause IBS symptoms by several mechanisms, such as a direct effect of food, changing gut microbiota, and immune activation^[32]. An elimination diet, such as low-FODMAP diet or GFD diet, represented an effective intervention for relieving gastrointestinal symptoms in patients with IBS^[33].

Table 1 Sociodemographic characteristics, *n* (%)

	IBS patients (<i>n</i> = 25)	Non-IBS participants (<i>n</i> = 178)	<i>P</i> value
Age, yr	36.0 (29.5, 43.0)	32.0 (28.0, 38.0)	0.215
Gender, male:female	10 : 15	71 : 107	0.991
Body mass index, kg/m ^{2a}	22.31 (21.22, 23.40) ^a	23.50 (21.3, 26.2)	0.033
Level of education ^a			0.007
Junior middle school	2 (8.0)	5 (2.8)	
Senior middle school	5 (20.0)	46 (25.8)	
Undergraduate	10 (40.0)	110 (61.8)	
Master degree or above	8 (32)	17 (9.6)	
Drinking			0.699
Yes	8 (32.0)	64 (36.0)	
No	17 (68.0)	114 (64.0)	
Smoking			0.753
Yes	6 (24.0)	48 (27.0)	
No	19 (76.0)	130 (73.0)	
Predominant bowel pattern			N/A
Diarrhea	7 (28)	N/A	
Constipation	5 (20)	N/A	
Mixed	9 (36)	N/A	
Unclassified	4 (16)	N/A	

The data are presented as the median (Q1, Q3) or numbers (percentages).

^a*P* < 0.05 *vs* controls.

IBS: Irritable bowel syndrome; N/A: Not applicable.

As we all know, food categories differed largely between the Eastern and Western diets^[17]. Moreover, the mostly used dietary questionnaires, especially FFQ, only evaluated the intake frequency of some foods^[19,21]. Thus, these diet questionnaires are not entirely suitable to evaluate the dietary habits of Asian populations, especially the Chinese. We constructed a new dietary questionnaire according to the eating habits of the Chinese, and “quantity per time” was included for analysis. It is the first study using a multidimensional questionnaire to investigate the dietary habits systematically and comprehensively between IBS patients and non-IBS participants in a community-based study. The formulation of the questionnaire has been completed in clinical practice before this study, and the reliability and validity test will be performed in the future.

To our delight, we found some clinically instructive findings. In our study, the consumption of soybean and its products, egg, and seafood were significantly increased in patients with IBS. Such differences have been confirmed in previous studies^[34,35]. Protein could be fermented to produce sulfur-containing and nitrogen-containing gases. A large amount of gas accumulated in enteric cavity and led to high intraluminal pressure, which then induced abdominal pain, abdominal discomfort, and other symptoms^[36,37]. In addition, metabolic products of protein fermentation, such as short-chain fatty acids and phenolic and indolic compounds, exerted harm in the intestinal tract depending on the imbalance among the rates of production, absorption, and excretion^[38]. Food allergy, characterized by activation of IgE-mediated antibodies to a food protein, was still controversial in the pathogenesis of IBS^[39]. Zuo *et al*^[40] reported that serum IgG antibody increased in IBS patients compared with health controls. However, no significant correlation was observed between symptom severity and elevated serum food antigen-specific IgG antibodies. Soybeans are rich in proteins and carbohydrates, which might participate in the pathogenesis of IBS through accumulated gaseous products and toxic metabolites of fermentation. In the multivariate analysis, the intake frequency of soybean and its products (≥ 7 t/wk) was

Table 2 Dietary habits, clinical characteristics, and psychological states of irritable bowel syndrome patients and non-irritable bowel syndrome participants, *n* (%)

	IBS patients	Non-IBS participants	<i>P</i> value
Dietary habits	<i>n</i> = 25	<i>n</i> = 110	
Quantity per time (g for solid food and mL for liquid food)			
Seafood	150 (100, 200)	100 (75, 150)	0.004
Soybean and its products	250 (150, 350)	200 (100, 250)	< 0.001
Spicy food	250 (150, 300)	200 (150, 250)	0.036
Dry-fried nuts	75 (50, 100)	62.5 (50, 75)	0.021
Soft drinks			< 0.001
0 mL	5 (20.0)	45 (40.9)	
250 mL	9 (36.0)	54 (49.1)	
500 mL	11 (44.0)	11 (10.0)	
Vegetables	350 (300, 400)	250 (200, 300)	< 0.001
Fruits	250 (200, 300)	200 (150, 250)	< 0.001
Intake frequency [times per week (t/wk)]			
Egg			0.019
≤ 1 t/wk	2 (8.0)	41 (37.3)	
2–6 t/wk	13 (52.0)	38 (34.5)	
≥ 7 t/wk	10 (40.0)	31 (28.2)	
Soybean and its products			< 0.001
≤ 1 t/wk	10 (40.0)	95 (86.4)	
2–6 t/wk	7 (28.0)	12 (10.9)	
≥ 7 t/wk	8 (32.0)	3 (2.7)	
Spicy food			0.001
≤ 1 t/wk	7 (28.0)	63 (57.3)	
2–6 t/wk	7 (28.0)	33 (30.0)	
≥ 7 t/wk	11 (44.0)	14 (12.7)	
Barbecue			< 0.001
≤ 1 t/wk	12 (48.0)	93 (84.5)	
2–6 t/wk	9 (36.0)	14 (12.7)	
≥ 7 t/wk	4 (16.0)	3 (2.7)	
Dry-fried nuts			< 0.001
≤ 1 t/wk	15 (60.0)	102 (92.7)	
2–6 t/wk	4 (16.0)	7 (6.4)	
≥ 7 t/wk	6 (24.0)	1 (0.9)	
Coarse grain			0.019
≤ 1 t/wk	9 (36.0)	54 (49.1)	
2–6 t/wk	3 (12.0)	36 (32.7)	
≥ 7 t/wk	13 (52.0)	20 (18.2)	
Clinical and psychological score	<i>n</i> = 25	<i>n</i> = 178	
IBS-SSS	150.0 (37.5, 187.5)	N/A	N/A
IBS-QOL	46.0 (35.5, 74.5)	N/A	N/A

GSRS	4.0 (3.0, 6.5)	3.0 (1.0, 5.0)	0.007
VSI	64.0 (53.0, 68.5)	29.0 (17.5, 38.25)	< 0.001
HADS anxiety score	7.0 (3.5, 10.0)	3.0 (1.0, 6.0)	< 0.001
HADS depression score	5.0 (2.5, 8.0)	3.0 (1.0, 6.0)	0.026

The data are presented as the median (Q1, Q3) or numbers (percentages). All $P < 0.05$ vs controls. IBS: Irritable bowel syndrome; IBS-SSS: IBS symptom severity scale; IBS-QOL: IBS-specific quality of life; VSI: Visceral sensitivity index; HADS: Hospital anxiety and depression scale; GSRS: Gastrointestinal symptom rating scale; N/A: Not applicable.

Table 3 Association between dietary factors and symptom scores/ psychological factors

	IBS-SSS		HADS (a)		HADS (d)	
	<i>r</i>	<i>P</i> value	<i>r</i>	<i>P</i> value	<i>r</i>	<i>P</i> value
Quantity per time						
Soybean and its products	0.415	0.039	0.635	0.001	0.604	0.001
Spicy food	0.590	0.002	0.454	0.022	0.483	0.014
Dry-fried nuts	0.738	< 0.001	0.608	0.001	0.616	0.001
Intake frequency						
Soybean and its products	0.702	< 0.001	0.422	0.036	0.566	0.003
Spicy food	0.691	< 0.001	0.451	0.024	0.424	0.034
Dry-fried nuts	0.512	0.009	0.605	0.001	0.622	0.001

All $P < 0.05$. IBS-SSS: Irritable bowel syndrome-symptom severity scale; HADS: Hospital anxiety and depression scale; a: Anxiety; d: Depression.

an independent risk factor for IBS. This also provided theoretical support to eliminate soybean and its products from diet structure in IBS patients.

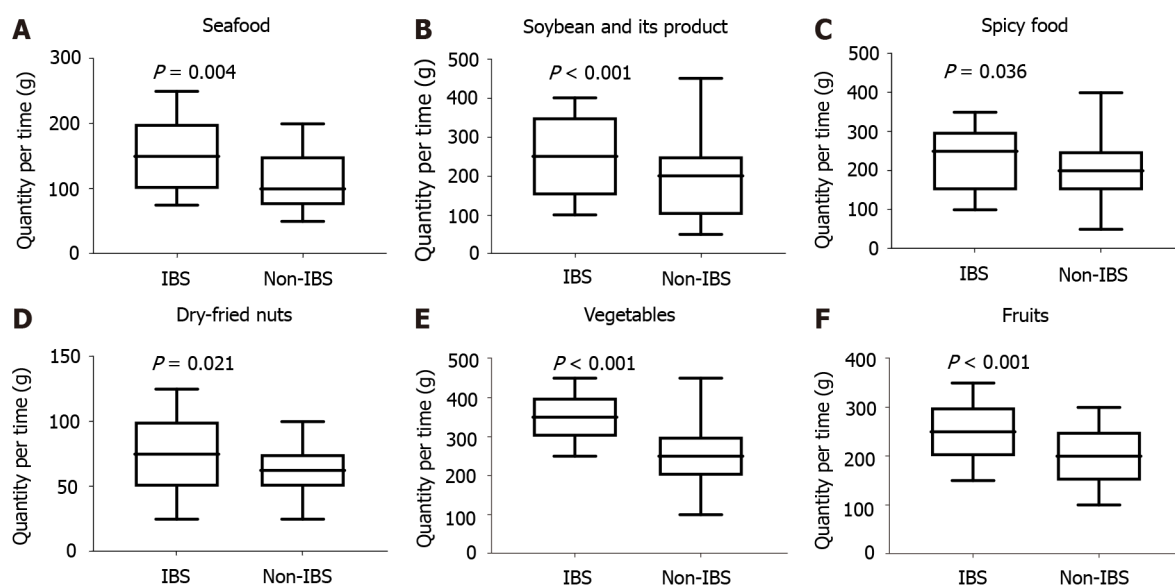
We also found that spicy foods differed between the two groups. Everyone knows that spicy foods contain capsaicin. Previous controlled studies have found that patients with functional dyspepsia and IBS were highly sensitive to capsaicin or capsaicin containing foods^[41,42]. Capsaicin could act on transient receptor potential vanilloid-1 (TRPV-1) and mediate visceral hypersensitivity^[43,44]. A multicenter study involving Korean and Japanese populations found that, regardless of TRPV-1 genotype and *Helicobacter pylori* infection status, upper gastrointestinal symptoms were more common in patients who ate more spicy foods^[45]. Contrary to expectations, long-term intake of capsaicin agonists or chilli could desensitize and improve symptoms. Compared with placebo, red pepper improved the dyspeptic symptoms effectively, in which the desensitization of gastric nociceptive C-fibers was attributed to capsaicin^[46]. This study found that IBS patients consumed more spicy foods in terms of quantity per time and intake frequency. Further studies are needed to confirm whether the correlation between capsaicin and functional gastrointestinal disorder (FGID) symptoms is related to duration time, single dose, and intake frequency.

In recent years, the effect of nuts has been widely concerned by scholars worldwide. Nuts are rich in antioxidants, particularly vitamin E and polyphenols, which exert antioxidant properties by mediating DNA repair, preventing lipid peroxidation, and regulating signaling pathways^[47]. However, some scholars also have found that foods could cause a variety of diseases after dry-fried or high-temperature processed. Oh *et al*^[48] revealed that the allergen activity of raw, dry-fried, and boiled walnuts differed, and the walnut allergen activity was reduced by thermal processing methods. Several studies have revealed that nutrient-sensing mechanisms existed in the gastrointestinal tract and resulted in the transmission of neuronal signals to the brain, particularly satiety^[49]. The taste of food was changed during high-temperature processing, which might be related with reduced gut-brain satiety signal. In addition, a large number of harmful substances were formed during high-temperature cooking, which could mediate tissue damage and cause mucosal low-grade inflammation^[50-52]. Other studies have shown that some food additives, such as artificial sweeteners, emulsifiers, and food colorants, could mediate inflammation and induce intestinal flora imbalance^[53-55].

Table 4 Evaluation of dietary factors for IBS by logistic regression analysis

	Univariable				Multivariable			
	OR	95%CI		P value	OR	95%CI		P value
		Lower	Upper			Lower	Upper	
Quantity per time								
Soybean and its products	1.009	1.004	1.014	0.001				
Spicy food	1.006	1	1.013	0.04				
Dry-fried nuts	1.032	1.01	1.054	0.004				
Intake frequency [times per week (t/wk)]								
Soybean and its products				< 0.001				0.015
≤ 1 t/wk	Ref			/				
2–6 t/wk	4.318	1.351	13.801	0.014	2.433	0.625	9.473	0.200
≥ 7 t/wk	23.03	5.314	99.804	< 0.001	11.613	2.145	62.855	0.004
Spicy food				0.002				0.184
≤ 1 t/wk	Ref			/				
2–6 t/wk	1.909	0.617	5.905	0.262				
≥ 7 t/wk	7.071	2.329	21.47	0.001				
Dry-fried nuts				0.001				0.078
≤ 1 t/wk	Ref			/				
2–6 t/wk	3.886	1.015	14.88	0.048				
≥ 7 t/wk	40.8	4.588	362.841	0.001				

CI: Confidence interval; OR: Odds ratio; Ref: Reference.

**Figure 1** Comparison of quantity per time between irritable bowel syndrome patients and non-irritable bowel syndrome participants. A: Seafood; B: Soybean and its products; C: Spicy food; D: Dry-fried nuts; E: Vegetables; F: Fruits. All $P < 0.05$ vs controls. IBS: Irritable bowel syndrome.

Our study found that the intake frequency and quantity per time of dry-fried nuts in IBS patients were higher than those of non-IBS participants. We speculated that dry-fried or high-temperature processed food might aggravate symptoms by changing food allergen activity, re-setting of satiety signal, and inducing gut inflammation by food additives or harmful substances. It is necessary to further explore the detailed

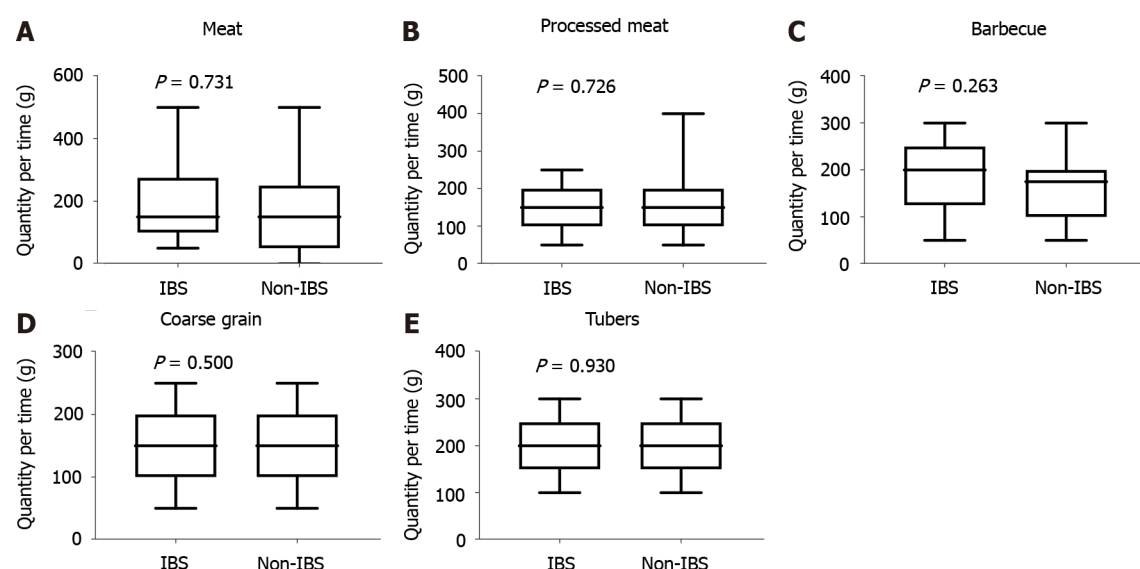


Figure 2 Comparison of quantity per time between irritable bowel syndrome patients and non-irritable bowel syndrome participants. A: Meat; B: Processed meat; C: Barbecue; D: Coarse grain; E: Tubers. All $P > 0.05$ vs controls. IBS: Irritable bowel syndrome.

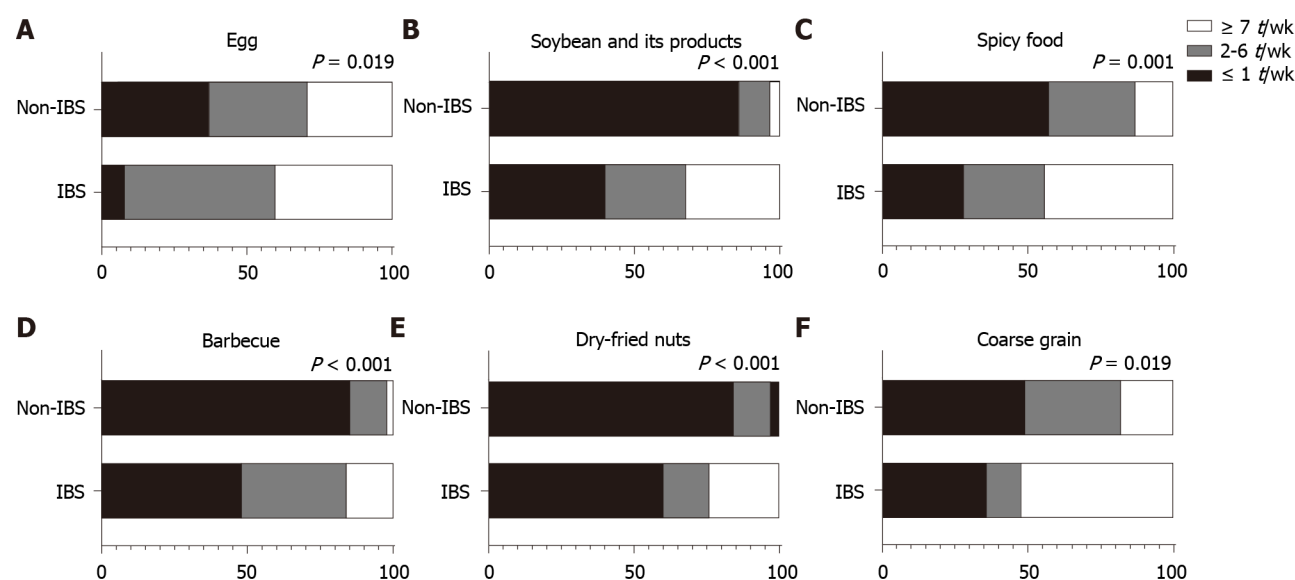


Figure 3 Comparison of intake frequency between irritable bowel syndrome patients and non-irritable bowel syndrome participants. A: Egg; B: Soybean and its products; C: Spicy food; D: Barbecue; E: Dry-fried nuts; F: Coarse grain. All $P < 0.05$ vs controls. IBS: Irritable bowel syndrome.

mechanisms *in vitro* and using animal experiments.

This study also found that IBS patients ate coarse grain more frequently. In fact, there are two types of dietary fiber in these foods: Soluble dietary fiber and insoluble dietary fiber. The role of dietary fiber in IBS remains to be determined. A meta-analysis of 22 studies found that soluble fiber improved assessment of symptoms, as well as the abdominal pain score. However, no improvement was observed in the insoluble fiber group^[56]. Another study has shown that there was no definitive recommendation supporting the use of fiber for children with IBS^[57]. Further prospective studies are needed to confirm the association or dose-response trend for different types of dietary fiber separately with risk of IBS.

In addition, soft drinks, vegetables, and fruits differed only in quantity per time between IBS patients and non-IBS participants. The soft drinks contained reducing sugars, which were poorly digested and absorbed. A large amount of reducing sugars accumulated in the enteric lumen and formed osmotic activity^[33]. Whether vegetables are protective or harmful may be related to vegetable varieties. It is generally accepted that onion, garlic, and chives could induce IBS symptoms^[58]. We found that IBS patients ate more vegetables and fruits at a time, and no positive results were found in

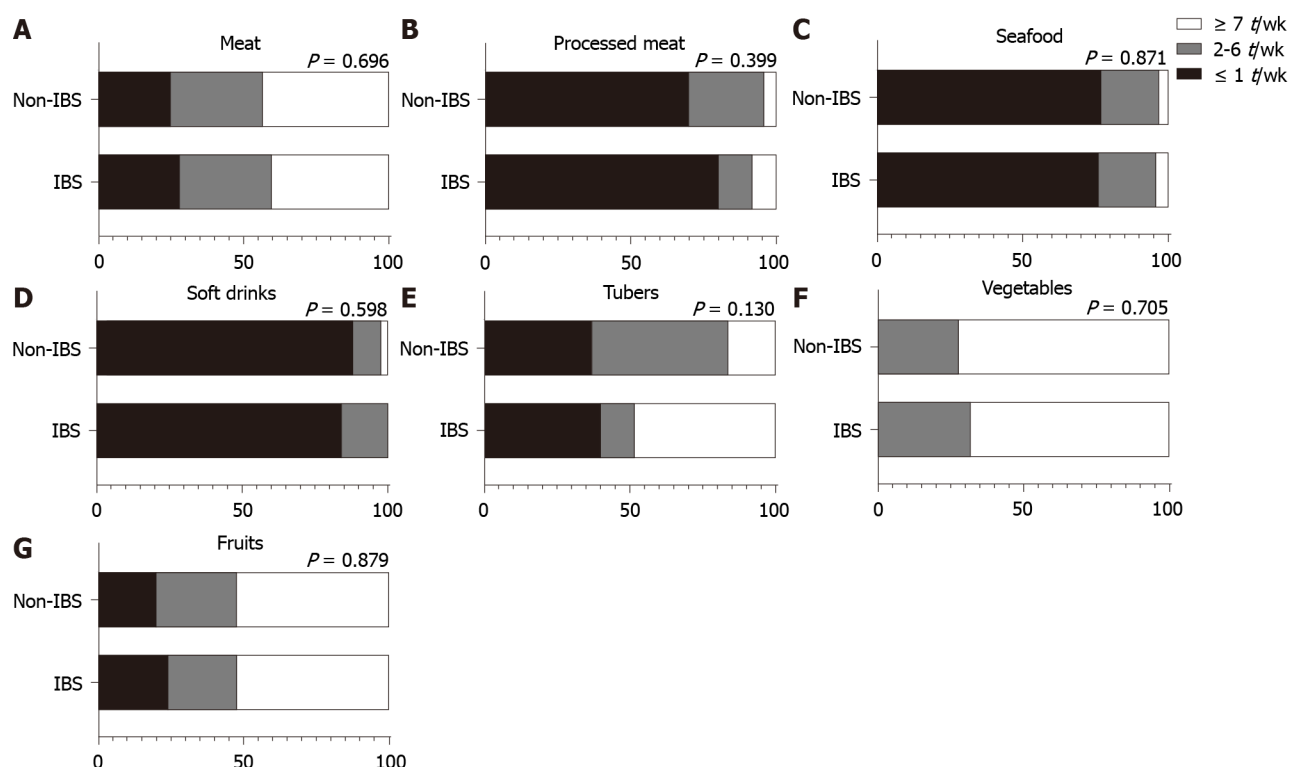


Figure 4 Comparison of intake frequency between irritable bowel syndrome patients and non-irritable bowel syndrome participants. A: Meat; B: Processed meat; C: Seafood; D: Soft drinks; E: Tubers; F: Vegetables; G: Fruits. All $P > 0.05$ vs controls. IBS: Irritable bowel syndrome.

the intake frequency. Therefore, we speculated that a single high-dose intake may lead to a sharp increase in intraluminal osmotic activity and liquid secretion, inducing symptoms. The results might be limited by the sample size. Further studies are still needed to clarify whether differences in the intake frequency of vegetables and fruits exist between IBS patients and health controls.

Unfortunately, no statistical differences were found in meat and processed meat intake between two groups. The results were not in line with those in previous studies^[21]. To our surprise, a study from Bangladesh found that less intake of meat was an important associated factor for IBS. These differences might be attributed to different eating habits among populations^[36]. It is necessary to refine the scale and enlarge the sample size to confirm whether differences exist in meat and processed meat between IBS patients and non-IBS participants.

In our study, IBS patients had visceral hypersensitivity, which was consistent with the results of previous studies^[6,59]. The mechanisms of visceral hypersensitivity in IBS patients are mainly related to visceral afferent nerve sensitization, increased excitability of neurons in the dorsal horn of spinal cord, and central sensory abnormalities. Visceral hypersensitivity is also characterized by a high response to dining. That is to say, dining could induce visceral hypersensitive symptoms, such as abdominal pain, abdominal distension, and abdominal discomfort^[60]. Previous studies have reported that IBS may overlap with other FGIDs^[61,62], thus making the illness more complicated to diagnose for clinicians. This might help explain why IBS patients had a higher score of GSRS questionnaire in our study. It is generally believed that psychological disorders might be closely related to IBS. In our study, the anxiety and depression scores of IBS patients were significantly increased according to HADS questionnaire. Psychological abnormalities could change autonomic nervous function, which led to gastrointestinal dysfunction and affected visceral sensation. In addition, due to visceral hypersensitivity and other reasons, the information captured by visceral receptors was amplified in the process of uploading to the central nervous system (CNS), thus affecting the state of the CNS and changing the emotional response^[63,64].

This study found that soybeans, spicy foods, and dry-fried nuts were positively correlated with symptoms and psychological scores. The correlations between symptom severity, psychological state, and diet were different among studies. Bennet *et al.*^[65] reported that the low FODMAP diet lasting 4 wk significantly reduced IBS-SSS by ≥ 50 , and had a significant impact on fecal bacteria^[65]. A study on pregnant women showed that low intake of soybeans was significantly associated with generalized

anxiety disorder^[66]. Compared with a healthy dietary pattern, Western dietary pattern was characterized by a higher consumption of meat and eggs, which increased the risk of current and subsequent depression^[67]. In our opinion, the damage caused by a low-dose intake or low intake frequency of some food could be quickly repaired. However, high-dose intake per time, high intake frequency, and long-term intake could lead to cumulative effects, exceeding the repairing ability of tissues, causing damage and inducing symptoms. Long-term dietary habits undoubtedly have effects on the intestinal ecosystem. The products of intestinal flora might stimulate the enteric nervous system and vagal afferents, and promote the activation of the hypothalamic-pituitary-adrenal axis^[68]. Further studies are needed to confirm our deduction.

To date, most studies have confirmed that the intake frequency of some food was independent risk factors for IBS, which used the FFQ. However, there was no difference in the food frequency in IBS patients compared with non-IBS patients sometimes. This study objectively reflected the eating habits of residents in a Chinese community. It is significant for guiding IBS patients to have a reasonable diet. The results also confirmed that the quantity per time of specific food might differed between IBS patients and non-IBS participants. Physicians should not make decisions simply depending on intake frequency, but on the basis of multidimensional questionnaire.

Our research also has some limitations. First, there were differences only in intake frequency or quantity per time in some foods, which may be limited by the sample size and need more detailed classification. Larger sample size studies are needed to confirm our results in the future. In addition, the diet questionnaire relies on memory rather than the use of diet diary, which could result in recall bias. Third, the reliability and validity test of the dietary questionnaire is needed in the subsequent experiments with sufficient samples. Last but not the least, the role of food ingredients and cooking methods has not been deeply studied. This requires further exploration in the subsequent experiments. Further studies should refine scale, expand the sample size, and adopt a prospective study design to delve into the role of diet in IBS.

CONCLUSION

In conclusion, this study has evaluated dietary differences between IBS patients and non-IBS participants from multiple perspectives, including food categories, intake frequency, and quantity per time. The intake frequency and quantity per time of soybean and its products, spicy foods, and dry-fried nuts are positively associated with clinical and psychological status. The intake frequency of soybean is a risk factor for IBS. These data suggest that some foods play a potential role in the occurrence and development of IBS.

ARTICLE HIGHLIGHTS

Research background

Previous studies have demonstrated that dietary factors could induce or aggravate irritable bowel syndrome (IBS) symptoms, which was evaluated mostly based on food frequency questionnaire. This study investigated the dietary habits between IBS patients and non-IBS participants from food categories, quantity per time, and intake frequency.

Research motivation

Our study aimed to explore the dietary differences between IBS patients and non-IBS participants from dietary categories, intake frequency, and quantity each time. These differences might be helpful for dietary guidance in the treatment of IBS.

Research objectives

To explore differences in dietary habits of people with *vs* without IBS and their correlation with symptom and psychological status.

Research methods

The participants were evaluated using multiple questionnaires (dietary questionnaire, IBS symptom severity scale (IBS-SSS), IBS quality of life, visceral sensitivity index,

hospital anxiety and depression score (HADS), and gastrointestinal symptom rating scale) to obtain clinical and psychological characteristics. These parameters were analyzed with SPSS version 26.0.

Research results

In this study, patients with IBS consumed more soybean and its products, spicy food, and dry-fried nuts in terms of quantity per time and intake frequency. They were positively associated with IBS-SSS, HADS anxiety score, and HADS depression score. Besides, seafood, soft drinks, vegetables, and fruits differed only in quantity per time. The intake frequencies of egg, barbecue, and coarse grain were statistically different. We also found that the intake frequency of soybean and its products (≥ 7 t/wk) was an independent risk factor for IBS.

Research conclusions

The dietary habits differ between IBS patients and non-IBS participants. The intake frequency and quantity per time of soybean and its products, spicy foods, and dry-fried nuts are positively associated with clinical and psychological status, and the intake frequency of soybean is a risk factor for IBS. These results suggest that some foods play a potential role in the occurrence and development of IBS.

Research perspectives

We preliminarily explored the dietary differences between the two groups. However, some limitations existed in this study. Further studies should refine scale, expand the sample size, and adopt a prospective study design to delve into the role of diet in IBS in the future.

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