J Nutr Health. 2024 Feb;57(1):75-87
https://doi.org/10.4163/jnh.2024.57.1.75
eISSN 2288-3959

JNH
Journal of Nutrition and Health

Research Article

Check for updates

Effect of web-based personalized nutrition management on gut microbiota in Korean patients with irritable bowel syndrome aged between 20 and 30 years

Woori Na [1], **Dayoung Oh** [1], **Seohyeon Hwang** [1], **and Cheongmin Sohn** [1,2]

[1]Department of Food and Nutrition, Wonkwang University, Iksan 54538, Republic of Korea
[2]Institute of Life Science and Natural resources, Wonkwang University, Iksan 54538, Republic of Korea

OPEN ACCESS

Received: Nov 22, 2023
Revised: Jan 10, 2024
Accepted: Jan 11, 2024
Published online: Feb 13, 2024

Correspondence to
Cheongmin Sohn
Department of Food and Nutrition, Wonkwang University, 460 Iksan-daero, Iksan 54538, Republic of Korea.
Tel: +82-63-850-6656
Email: ccha@wku.ac.kr

ORCID iDs
Woori Na
https://orcid.org/0000-0002-5670-4520
Dayoung Oh
https://orcid.org/0000-0002-4530-2294
Seohyeon Hwang
https://orcid.org/0000-0002-7966-3805
Cheongmin Sohn
https://orcid.org/0000-0003-0529-7037

Funding
This work was supported by the National Research Foundation of Kore (NRF) grant funded by the Korea Government (MSIP) (No. NRF-2020R1A2C1014177).

ABSTRACT

Purpose: Dietary habits are strongly related to the symptoms of people with irritable bowel syndrome (IBS). Therefore, personalized nutrition management can help reduce symptoms and improve the quality of life of people with IBS. This study assessed the effectiveness of a personalized web-based nutrition management based on the types of food that trigger IBS symptoms.

Methods: Sixty Korean adults with IBS according to Rome IV criteria in their 20s and 30s were enrolled in this study. The data from the final 49 patients who completed a three-month personalized nutrition intervention were analyzed. The general information, anthropometry, dietary intake survey, and gut microbiota were examined pre and post-intervention. The gut microbiota analysis included the relative abundance and the Shannon index. The food intake was recorded for two days for personalized nutrition education, followed by three months of personalized nutrition intervention. Statistical analysis was performed using the Wilcoxon signed-rank test in SPSS 26.0, with the significance set to $p < 0.05$.

Results: The relative abundance of the gut microbiota changed after personalized nutrition management, with a significant decrease in the presence of *Veillonella* ($p = 0.048$). Furthermore, when the gut microbiota was analyzed according to the type of food that triggers symptoms, the diversity was increased significantly in the high fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs) type ($p = 0.031$) and FODMAPs-containing gluten-type personalized nutrition intervention types ($p < 0.001$).

Conclusions: Gut microbial diversity and gut microbiota distribution changed after using web-based personalized nutrition management. Hence, personalized nutrition management that considers trigger foods may improve IBS symptoms.

Keywords: irritable bowel syndrome; nutrition therapy; precision medicine; microbiota; Korea

INTRODUCTION

The mechanism underlying irritable bowel syndrome (IBS) is still unclear, but it is known to be a disorder characterized by recurrent episodes of abdominal pain, abdominal discomfort, and diarrhea that impair the quality of life [1]. The main factors associated with IBS

Conflict of Interest
There are no financial or other issues that might lead to conflict of interest.

Author Contributions
Conceptualization: Sohn C; Data curation: Oh D, Hwang S; Formal analysis: Na W; Funding acquisition: Sohn C; Methodology: Na W; Writing - original draft: Na W; Writing - review & editing: Sohn C.

symptoms are altered gut motility and sensitivity, brain-gut dysregulation, stress, socio-psychological factors, altered gut microbiota, and dietary intake [2]. Dietary intake is closely related to symptom expression, depending on the individual's ability to regulate it [3], and dietary interventions to alleviate IBS symptoms have been studied extensively in recent years.

Fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs) are the most common dietary factors associated with IBS symptoms; however, there are many other factors, including dairy products, dietary fiber, alcohol consumption, caffeine consumption, spicy foods, high-fat foods, and fluid intake [4]. It is believed that each of these factors may play a different role in triggering symptoms in different individuals, and that there may also be a combination of factors. Therefore, personalized nutrition management is required to identify and address individual triggers for effective symptomatic relief in patients with IBS.

Education and counseling with a registered dietitian can help identify the cause and provide ongoing management. IBS has the highest prevalence among young adults in their 20s and 30s, but physical visits to doctors do not lead to treatment, which can lead to chronic discomfort and reduced labor productivity [5]. Alternatives include self-monitoring in a mobile environment and personalized management of an individual's dietary habits by a registered dietitian. Several previous studies have evaluated the effectiveness of mobile nutrition management for IBS patients, including the development and use of an FODMAP-related app for IBS patients, the effectiveness of a nutrition education program applying a FODMAPs diet, and the effectiveness of a low-FODMAP diet suggestion app [6].

An individual's dietary intake affects the composition of the gut microbiota, which in turn affects the overall metabolism and disease [7]. The gut microbiota produces vitamins, essential amino acids, and short-chain fatty acids, which are used as the main energy sources by intestinal epithelial cells to strengthen the barrier [8,9]. In addition, the gut microbiota is of increasing interest because of its various functions in the body, including contribution to intestinal and systemic immunity [10,11]. However, to date, most of the studies that have implemented nutrition management using mobile devices for patients with IBS have focused on FODMAPs, or the evaluation items have focused on satisfaction with education, nutritional knowledge, and symptom severity. There is a lack of research on the substrate intestinal effects of personalized nutrition management.

Therefore, in this study, we aimed to evaluate the effectiveness of a personalized nutrition management according to the types of foods that trigger IBS symptoms and evaluated the changes in gut microbiota.

METHODS

Design and study participants

This was a single-arm trial with a pre-post test design to evaluate changes in the gut microbiota distribution after implementing personalized nutrition management for symptom relief in patients with IBS. The participants of the study were Korean adults in their 20s and 30s.

https://doi.org/10.4163/jnh.2024.57.1.75

The number of participants in the study was calculated using G-power 3.1 with a paired t-test, effect size 0.5 and significance level less than 0.05, resulting in a total of 45 persons. Considering the dropout rate of 30%, the number of participants was calculated to be 58.5 persons, so the final number of participants was rounded up to 60 persons. Participants were recruited from adults in their 20s and 30s who agreed to participate in the study online from April to August 2022 and were diagnosed with IBS using Rome IV criteria [12]. The exclusion criteria included patients with inflammatory bowel disease, those taking medications that affect intestinal and gastric tract diseases, and those who did not agree to participate in the study. Participants received the intervention according to an individualized nutrition education protocol based on to the type of IBS food trigger developed in a previous study [13]. To apply the 12-week web-based nutrition education program to all participants, we explained how to use the content (mobile app: Foo_DIBS, interactive platform: KakaoTalk channel, and individual and shared educational materials) developed before the intervention. For 12 weeks, the mobile app and interactive platform were freely available, personalized nutrition education materials were provided every 2 weeks, and common education materials were provided to all participants every 1 week based on the analysis of the meal intake survey data collected through the mobile app.

During the 12-week nutrition management program, 11 participants dropped out due to loss of contact or difficulty continuing to participate, and 49 participants were finally selected. This study was approved by the Institutional Review Board of Wonkwang University (WKIRB-202204-HR-033).

Evaluation measures

To evaluate changes in the distribution of intestinal microorganisms in response to personalized nutrition management for symptomatic relief in patients with IBS, we conducted a general health assessment, diagnosis of IBS (Rome IV), dietary intake survey, and intestinal microbiota test before and after nutritional intervention.

Diagnosis of IBS

The IBS Module of Drossman's Rome IV Adult Questionnaire was used to diagnose IBS, and IBS was diagnosed if at least two of the following three questions were satisfied [12]. 1) Symptoms persisting for more than 6 months; 2) abdominal pain averaging more than 1 time/week for the past 3 months; and 3) changes in the number and type of bowel movements (constipation and diarrhea) or pain associated with bowel movements. Questions related to stool morphology were categorized using the Bristol Stool Scale developed by O'Donnell et al. [14], in which types 1 and 2 were constipation, types 3 and 4 were normal, and types 5, 6, and 7 were diarrhea.

Health status assessment

Physical activity was calculated as metabolic equivalent task (min/week) for the past 7 days using the Korean version of the short-form International Physical Activity Questionnaire. After summation, those with fewer than 600 METs were categorized as inactive, those with 600–3,000 METs as minimally active, and those with more than 3,000 METs as health-promoting physical activity [15]. The Brief Encounter Psychosocial Instrument, Korean version, was used to assess stress [16]. Each item was rated on a scale of 1 to 5, with answers of "never," "rarely," "moderately," "often," and "very often," and low stress was categorized as less than 1.8, moderate stress as less than 1.8 to 2.8, and high stress as more than 2.8.

https://doi.org/10.4163/jnh.2024.57.1.75

IBS severity scoring system (IBS-SSS)

The severity of IBS symptoms was measured using the Korean version of the IBS-SSS developed by Francis et al. [17]. The IBS-SSS consists of seven questions on the presence, duration, and level of abdominal pain, discomfort, satisfaction with bowel symptoms, and extent to which bowel symptoms interfere with daily life. Questions about the presence or absence of abdominal pain or bloating were excluded from the score calculation, and the remaining five questions were scored on a 0–100 scale for a total of 500 points, and according to the total score, 75–174 points were classified as mild, 175–299 points as moderate, and 300–500 points as severe.

Food intake survey and nutrition education program

For nutrient analysis, the Computer-Aided Nutritional Analysis Program for Professionals (CAN PRO 5.0; Korean Nutrition Society, Seoul, Korea) developed by the Korean Nutrition Society was used. Data from previous studies were used to calculate the FODMAPs intake [18]. In this study, we conducted a 2-day food intake survey of all participants, and then categorized the seven food types that trigger IBS symptoms using a method derived from a previous study [13]. The classification method calculated the number of times each food type was consumed and the amount of food consumed, and the food type with the highest intake was selected according to symptom onset. The number of times each food type was consumed and the amount of food consumed were as follows; high FODMAPs: 36, high fat: 27, FODMAPs-containing gluten: 19, spicy: 8, dairy: 6, caffeine: 4, alcohol: 3. Specific foods for each food type are presented in previous studies [18]. All participants were provided with common educational materials on basic IBS education contents and personalized nutrition education materials according to IBS symptoms trigger food type. The contents of the personalized nutrition education were different for each type, including recommended foods, alternative foods, recommended eating behaviors, and situational tips. The specific educational contents were presented in a previous study [13].

DNA extraction and sequencing

Stool samples were stored at 4°C for less than 24 hours and then stored at −80°C until DNA extraction. Genomic DNA was extracted from the stool samples using DNeasy. PowerSoil Pro Kit (QIAGEN, Hilden, Germany; Cat#47016) following the manufacturer's instructions. Library construction and sequencing were performed using Theragen Bio. Co. (Seongnam, Korea) were used. Microbiome data processing was performed using QIIME2, with minor modifications, following the official website (https://docs.qiime2.org/2021.11/tutorials/). Briefly, the illumina adaptor sequences were trimmed from raw sequencing reads using CutAdapt (v1.11). The DADA2 plug-in was used for quality filtering, denoising, merging, and chimeric removal. The 16S rRNA V4 gene sequences were aligned to a SILVA reference database (v.138) using the QIIME2 plugin feature-classifier. Amplicon sequence variants were assigned to 16 s rRNA databases. Finally, the microbiome data were analyzed, and the relative abundance was derived from the OTU values.

Statistical analysis

Statistical analyses were conducted to assess the effectiveness of personalized nutrition management. Frequencies and percentages were calculated for categorical variables and continuous variables were summarized as means and standard deviations. To compare pre- and post-intervention changes in the gut microbiota and dietary intake, we calculated the Shannon index at the genus level to determine the relative abundance of the gut microbiota. The pre-post nutrient intake of the 49 participants and changes in the distribution of the

https://doi.org/10.4163/jnh.2024.57.1.75

gut microbiota were analyzed using the Wilcoxon signed-rank test. Statistical analyses were performed using the R package and SPSS version 26.0. (SPSS Inc., Chicago, IL, USA) A significance level of $p < 0.05$ was considered to determine statistical significance.

RESULTS

General characteristics of the study participants

The general characteristics of the study participants are presented in **Table 1**. The participants were 15 (30.6%) males and 34 (69.4%) females, with a mean age of 26.5 ± 5.1 years. The BMI was 23.8 ± 5.5 kg/m^2, obesity status was underweight in 7 (14.3%), normal in

Table 1. General information about final study participants

Variables	Values
Sex	
Male	15 (30.6)
Female	34 (69.4)
Age (yrs)	26.5 ± 5.1
BMI (kg/m^2)	23.8 ± 5.5
Obesity status	
Underweight	7 (14.3)
Normal	20 (40.8)
Overweight	6 (12.2)
Obese	16 (32.7)
Occupation	
Student	28 (57.1)
Employed	15 (30.6)
Unemployed	6 (12.2)
Physical activity status	
Low-intensity activity	10 (20.4)
Moderate activity	28 (57.1)
Vigorous activity	11 (22.4)
Stress status	
Low	5 (10.2)
Medium	14 (28.6)
High	30 (61.2)
IBS subtypes	
IBS-constipation	3 (6.1)
IBS-diarrhea	31 (63.3)
IBS-multiple	10 (20.4)
IBS-unclassified	5 (10.2)
IBS severity scoring system	
Score	239.4 ± 89.4
Mild	12 (24.5)
Moderate	19 (38.8)
Severe	15 (30.6)
No response	3 (6.1)
IBS trigger food type	
High FODMAPs	6 (12.2)
High fat	9 (18.4)
FODMAPs-containing gluten	18 (36.7)
Spicy	7 (14.3)
Dairy	8 (16.3)
Caffeine	1 (2.0)
Alcohol	0 (0.0)

Values are presented as mean ± SD or number (%).
BMI, body mass index; IBS, irritable bowel syndrome; FODMAPs, fermentable oligosaccharides, disaccharides, monosaccharides, and polyols.

https://doi.org/10.4163/jnh.2024.57.1.75

20 (40.8%), overweight in 6 (12.2%), and obese in 16 (32.7%). Physical activity levels were low intensity activity in 10 (20.4%), moderate activity in 28 (57.1%), vigorous activity in 11 (22.4%), and stress status levels were low stress in 3 (10.2%), moderate stress in 14 (28.6%), and high stress in 30 (61.2%). The subtypes of IBS were constipation in 3 (6.1%), diarrhea in 31 (63.3%), combined in 10 (20.4%), and unclassified in 5 (10.2%); the mean IBS-SSS was 239.4 ± 89.4, with 12 (24.5%) mild, 19 (38.8%) moderate, 15 (30.6%) severe, and 3 (6.1%) unresponsive. The general characteristics of food type of IBS symptom triggers are presented in **Supplementary Table 1**.

Change of gut microbiome analysis at the genus level

Change of the relative abundance of participants' gut microbiota after the nutrition education program shown in **Fig. 1**. The relative abundance of the gut microbiota after the nutrition education program showed a slight change in distribution across all participants (A, B). Among the individual gut microbes, *Veillonella* showed a significant decrease in relative abundance after the nutritional intervention (p = 0.048) (C).

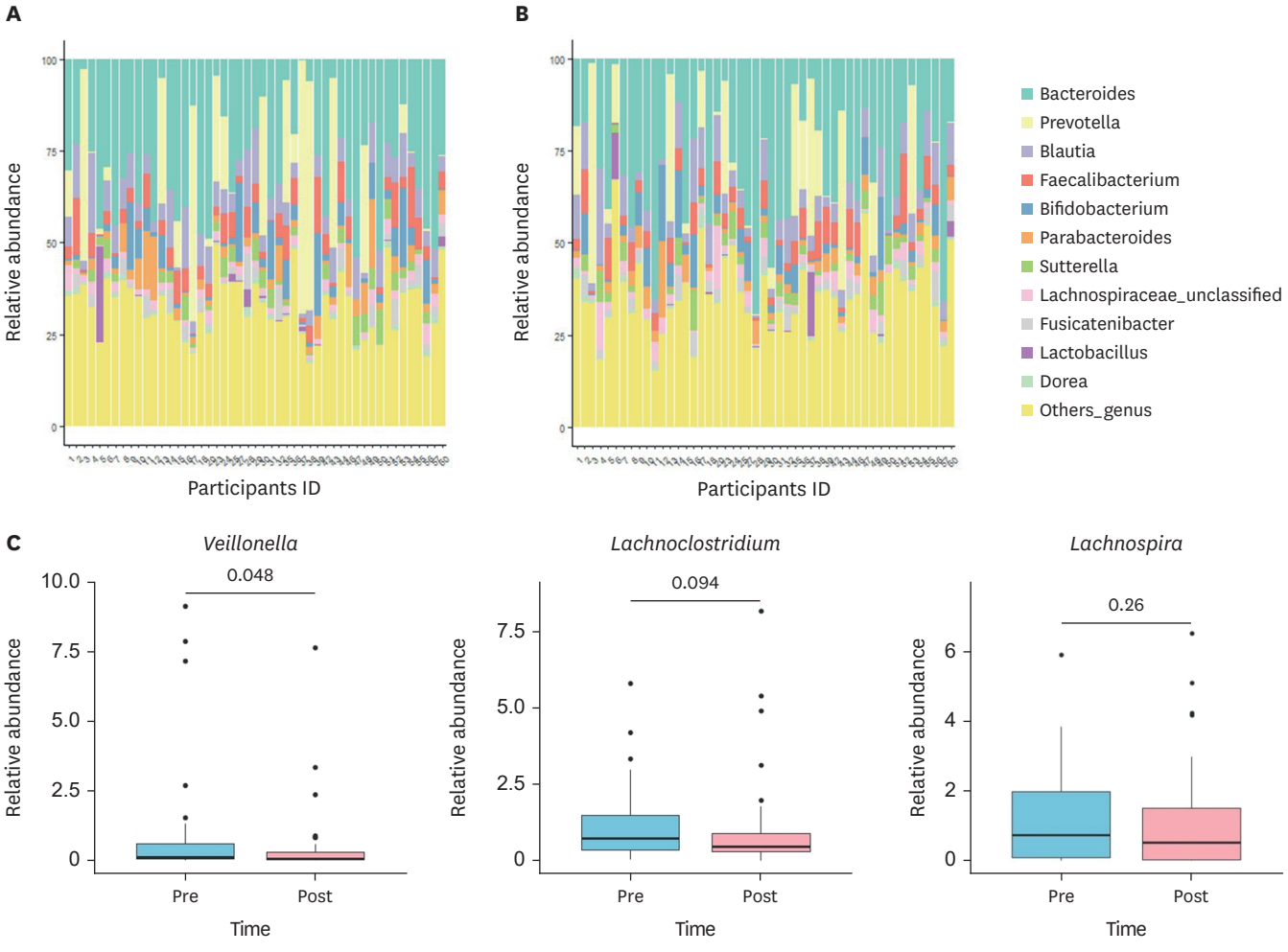

Fig. 1. Gut microbiome analysis at the genus level pre and post a personalized nutrition education program.
(A, B) Stacked bar plots indicated the proportional relative abundance of gut microbiome genus level that is present at 1% or more in the overall mean in participants (A; pre, B; post). (C) After providing personalized nutrition education, we evaluated the changes in the relative abundance of gut microbiome. The statistical analysis was conducted Wilcoxon signed rank test, with a significance level set at $p < 0.05$.

https://doi.org/10.4163/jnh.2024.57.1.75

Changes in gut microbiome diversity (Shannon index) according to IBS symptom trigger food types

The results of the analysis of the gut microbiota diversity according to the type of food that triggered IBS symptoms after the personalized nutrition education program are shown in **Fig. 2.** Among the types of foods that triggered IBS symptoms, the groups corresponding to high FODMAPs type ($p = 0.031$) and FODMAPs-containing gluten type ($p < 0.001$) were significantly increased. The high-fat type, spicy foods type, and dairy type also showed an increase in gut microbial diversity, although no significant differences were found.

Change in symptom severity of IBS

Fig. 3 shows the change in the IBS-SSS from pre- to post-test based on the type of food that triggered the participants' symptoms. For the high FODMAPs type, the score increased from 195.0 before nutrition education to 228.3. However, for the high-fat type, FODMAPs-containing gluten type, spicy foods type, dairy type, and caffeine types, IBS-SSS decreased. High fat type decreased from 192.2 before the nutrition education to 180.0 after the program. The FODMAPs-containing gluten type decreased from 244.4 to 204.4, and the caffeine type decreased from 340.0 to 300.0. In particular, the spicy foods type significantly decreased from 300.0 to 155.7 nutrition education ($p = 0.030$), and the dairy type significantly decreased from 248.8 to 161.3 before the nutrition education ($p = 0.007$).

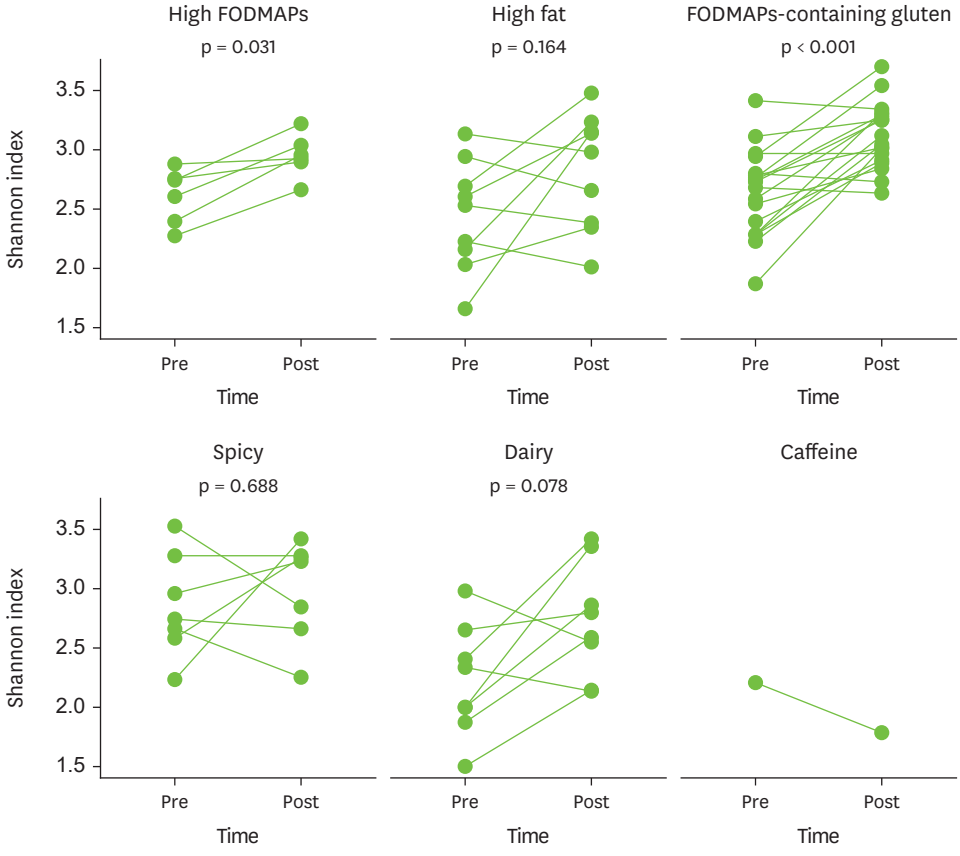

Fig. 2. Changes in gut microbiome diversity (Shannon index) after a personalized nutrition education program according to irritable bowel syndrome symptom trigger food types.
The statistical analysis was conducted using Wilcoxon signed rank test, with a significance level set at $p < 0.05$.
FODMAPs, fermentable oligosaccharides, disaccharides, monosaccharides, and polyols.

https://doi.org/10.4163/jnh.2024.57.1.75

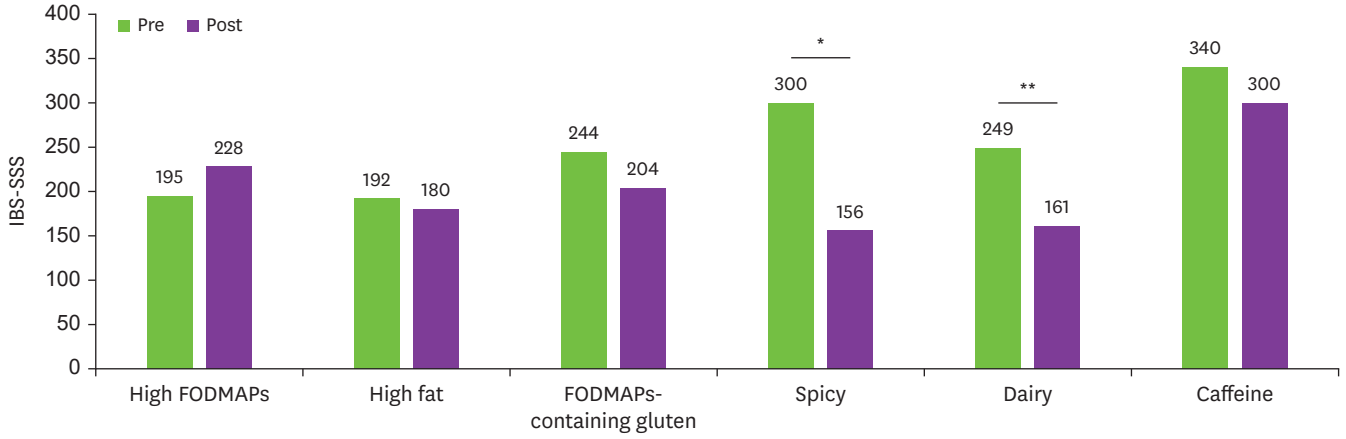

Fig. 3. Change in symptom severity of irritable bowel syndrome after nutritional intervention according to IBS-SSS by trigger food type.
This analysis was conducted using the SPSS and Wilcoxon signed rank test.
IBS-SSS, irritable bowel syndrome severity scoring system; FODMAPs, fermentable oligosaccharides, disaccharides, monosaccharides, and polyols.
Significance levels are represented as follows; *p < 0.05, **p < 0.01.

Change in nutrient intake

The pre- and post-treatment dietary intake changes of the participants according to the IBS-triggering food type are shown in **Table 2**. In the high FODMAPs type, carbohydrate intake decreased significantly from 242.3 ± 98.3 g/day to 174.7 ± 47.4 g/day (p = 0.046), protein intake from 82.1 ± 40.5 g/day to 56.5 ± 26.0 g/day (p = 0.046), and fructan intake from 6.0 ± 4.8 g/day to 3.9 ± 4.0 g/day (p = 0.046). In the high fat type, total energy intake was significantly reduced from 1,805.7 ± 721.2 g/day to 1,559.2 ± 769.2 g/day (p = 0.038), and fat intake was also significantly reduced from 69.1 ± 37.7 g/day to 51.5 ± 32.6 g/day (p = 0.038). In contrast, in the FODMAPs-containing gluten type, the total energy intake and intake of major energy sources, carbohydrates, proteins and fats increased. In particular, the intake of carbohydrates increased significantly from 231.2 ± 99.4 g/day to 251.7 ± 90.6 g/day (p = 0.043). Total energy intake decreased for the spicy foods type and dairy types, but the difference was not statistically significant.

DISCUSSION

In this study, we analyzed the gut microbiota after 12 weeks of customized nutritional education for each type of food that triggers IBS symptoms, and found that *Veillonella* was significantly reduced after personalized nutrition education. In addition, high FODMAPs type and FODMAPs-containing gluten type had a significant increase in Shannon index, showing a difference in the diversity of gut microbiota after nutrition education according to the IBS symptom trigger food type.

In the case of the participants in this study, six food types were categorized as triggering IBS symptoms, of which FODMAPs-containing gluten type was the highest with 18 people (36.7%), followed by high fat type with 9 (18.4%), dairy type with 8 (16.3%), spicy foods type with 7 (14.3%), high FODMAPs with 6 (12.2%), and caffeine with 1 (2.0%). In a study that analyzed foods that cause IBS symptoms in Koreans, a normal group, a non-IBS group diagnosed through Rome III, and an IBS group were compared among outpatients at a tertiary hospital, and the food groups that were problematic for IBS symptoms were high FODMAPs foods, high-fat foods, gluten foods, dairy products, and caffeine in both non-IBS

https://doi.org/10.4163/jnh.2024.57.1.75

Journal of Nutrition and Health

Table 2. Change in nutrient intake after personalized nutrition education program according to irritable bowel syndrome symptom trigger food types

Variables	High FODMAPs (n = 6)			High fat (n = 9)			FODMAPs-containing gluten (n = 18)			Spicy (n = 7)			Dairy (n = 8)			Caffein (n = 1)		
	Pre	Post	p-value	Pre	Post	p-value	Pre	Post	p-value	Pre	Post	p-value	Pre	Post	p-value	Pre	Post	p-value
Total energy (kcal)	1,993.1 ± 874.0	1,352.0 ± 353.4	0.116	1,805.7 ± 721.2	1,559.2 ± 769.2	0.038	1,884.1 ± 691.5	1,995.0 ± 720.7	0.586	1,314.0 ± 605.0	1,374.5 ± 510.0	0.499	1,694.2 ± 571.3	1,456.4 ± 202.5	0.263	2,473.9	2,059.6	
Carbohydrates (g)	242.3 ± 98.3	174.7 ± 47.4	0.046	223.3 ± 93.3	209.3 ± 88.8	0.214	231.2 ± 99.4	251.7 ± 90.6	0.043	173.8 ± 58.5	185.3 ± 68.5	0.499	231.0 ± 98.4	194.6 ± 43.7	0.484	158.5	252.0	
Proteins (g)	82.1 ± 40.5	56.5 ± 26.0	0.046	72.6 ± 32.2	64.8 ± 35.4	0.441	84.9 ± 32.2	85.8 ± 36.6	0.744	57.0 ± 20.7	64.0 ± 31.6	0.499	61.5 ± 15.0	57.3 ± 17.0	0.401	153.3	73.2	
Fat (g)	77.3 ± 43.7	47.5 ± 14.6	0.075	69.1 ± 37.7	51.5 ± 32.6	0.038	68.9 ± 27.5	71.7 ± 36.5	0.777	49.1 ± 22.5	41.9 ± 15.0	0.237	58.3 ± 26.4	49.9 ± 15.3	0.575	136.3	84.3	
CHO:PRO:FAT (%)	48.6:16.5 :34.9	51.7:16.5 :31.8		49.5:16.1 :34.4	55.8:16.6 :27.6		49.1:18.0 :32.9	51.2:17.5 :31.3		50.9:16.7 :32.4	53.9:17.9 :28.2		54.5:14.5 :31.0	53.4:15.5 :31.1		25.6:24.8 :49.6	49.0:14.2 :36.8	
Dietary fiber (g)	24.5 ± 11.3	13.0 ± 4.9	0.028	16.8 ± 4.8	11.6 ± 4.9	0.008	17.3 ± 10.3	15.1 ± 8.1	0.647	13.3 ± 8.5	13.1 ± 2.2	0.735	15.8 ± 6.1	14.0 ± 4.1	0.889	19.0	17.9	
Total sugars (g)	44.0 ± 22.8	38.4 ± 22.0	0.463	37.0 ± 28.5	35.5 ± 22.8	0.767	43.9 ± 27.2	47.5 ± 29.4	0.528	44.0 ± 29.0	31.9 ± 9.5	0.091	39.9 ± 15.6	50.2 ± 31.4	0.401	33.7	17.3	
Total FODMAPs (g)	9.1 ± 6.5	7.5 ± 6.6	0.345	7.7 ± 5.1	5.8 ± 4.7	0.374	7.3 ± 5.6	6.5 ± 4.4	0.744	7.2 ± 5.2	4.9 ± 2.6	0.237	7.8 ± 6.2	5.2 ± 2.1	0.327	9.1	5.7	
Sorbitol (g)	0.4 ± 0.4	0.1 ± 0.2	0.138	0.3 ± 0.4	0.2 ± 0.2	0.236	0.1 ± 0.1	0.2 ± 0.4	0.828	0.1 ± 0.2	0.1 ± 0.1	0.866	0.3 ± 0.4	0.0 ± 0.1	0.123	0.1	0.1	
Mannitol (g)	0.2 ± 0.1	0.0 ± 0.0	0.028	0.3 ± 0.5	0.1 ± 0.1	0.553	0.4 ± 1.2	0.3 ± 0.5	0.420	0.0 ± 0.1	0.0 ± 0.0	0.104	0.5 ± 0.8	0.2 ± 0.3	0.326	0.2	0.1	
Raffinose (g)	0.1 ± 0.0	0.1 ± 0.0	0.752	0.0 ± 0.0	0.0 ± 0.0	0.093	0.0 ± 0.0	0.0 ± 0.0	0.831	0.0 ± 0.0	0.0 ± 0.0	0.612	0.0 ± 0.1	0.0 ± 0.0	0.401	0.1	0.0	
Stachyose (g)	0.0 ± 0.0	0.0 ± 0.0	0.593	0.0 ± 0.0	0.0 ± 0.0	0.465	0.0 ± 0.1	0.0 ± 0.0	0.042	0.0 ± 0.0	0.0 ± 0.0	0.180	0.0 ± 0.0	0.0 ± 0.1	0.285	0.0	0.0	
Lactose (g)	2.4 ± 3.0	3.2 ± 6.1	0.753	3.2 ± 5.4	2.8 ± 3.8	0.953	3.1 ± 5.2	2.1 ± 3.3	0.435	3.4 ± 4.5	1.2 ± 1.8	0.116	2.8 ± 5.0	1.0 ± 1.2	0.401	4.6	0.1	
Fructan (g)	6.0 ± 4.8	3.9 ± 4.0	0.046	3.8 ± 2.3	2.7 ± 1.6	0.441	3.5 ± 1.9	3.8 ± 2.3	0.586	3.0 ± 1.9	3.5 ± 1.9	0.398	4.0 ± 2.0	3.8 ± 1.7	0.779	3.6	5.5	
Excess fructose (g)	0.2 ± 0.3	0.2 ± 0.2	1.000	0.0 ± 0.1	0.0 ± 0.0	0.109	0.1 ± 0.4	0.1 ± 0.4	0.600	0.1 ± 0.2	0.1 ± 0.1	0.285	0.1 ± 0.3	0.1 ± 0.3	1.000	0.5	0.0	

Values are presented as mean ± SD.
This analysis was conducted using the SPSS and Wilcoxon signed rank test.
FODMAPs, fermentable oligosaccharides, disaccharides, monosaccharides, and polyols; CHO:PRO:FAT, carbohydrate:protein:fat.

https://e-jnh.org

https://doi.org/10.4163/jnh.2024.57.1.75

and IBS groups [19]. In addition, in a study that categorized the types of foods that trigger IBS symptoms through a dietary intake survey of 1,000 Korean adult, 186 of those surveyed were selected as non-IBS, and the food types that triggered IBS symptoms were gluten containing FODMAPs, high fat, high FODMAPs, unfair, dairy, caffeine and alcohol [18]. In the present study, the food type with the highest percentage of symptom-inducing food intake was selected as the food type for nutritional management through a dietary intake survey; therefore, a direct comparison with the previous two studies is not possible, but it can be said that the high-fat and FODMAPs-containing gluten types are similar in that they were selected as the top foods that cause symptoms in common, including in this study.

Analysis of the relative abundance of the gut microbiota in all participants following personalized nutritional intervention showed that *Veillonella* was significantly reduced after nutritional intervention, and *Lachnoclostridium* and *Lachnospira* were also slightly reduced. Several studies have shown that *Veillonella* is significantly more prevalent in patients with IBS than in controls [20-22]. It is reported to play a role in converting lactate to acetate and propionic acid, and may affect the symptoms of patients with IBS by regulating pH and changing the intestinal environment [23,24]. In addition, Zhu et al. [25] found that *Lachnoclostridium* and *Lachnospira* were also higher in IBS patients than in healthy individuals, and it has been speculated that the overproduction of organic acids may worsen constipation symptoms by inhibiting mucin secretion [26]. In light of these previous studies, we believe that the personalized nutrition management in this study may have helped improve symptoms by properly balancing the gut microbiome.

The analysis of changes in gut microbial diversity according to IBS symptom triggering food type showed a significant increase in high FODMAPs type and FODMAPs-containing gluten type, and a slight increase in other types, except for caffeine. The gut microbiota diversity is lower in patients with IBS than in healthy individuals [22,27,28] and is known to be involved in the pathophysiology of IBS [29]. It is important to induce changes in the gut microbiota to improve the host environment for ongoing management, with the primary goal of symptomatic relief. In this study, we conducted continuous nutrition education and counseling with the participants through a mobile application and interactive platform (KakaoTalk channel), according to a personalized nutrition management protocol, which may have influenced food intake and dietary habits. In this study, the results of nutrient intake according to the type of food triggering IBS symptoms in the participants pre and post-intervention showed that the high FODMAPs type significantly decreased carbohydrate, dietary fiber, fructan, and protein levels; the high fat type significantly decreased energy, fat, and dietary fiber levels; and the FODMAPs-containing gluten type significantly increased only carbohydrates, with no significant difference in other types. These changes in nutrient intake are likely a reflection of the specifics of each individualized nutritional plan, which may have influenced the changes in the gut microbiome.

Analysis of the IBS-SSS according to the type of food triggering IBS symptoms showed a significant decrease in the spicy foods type and dairy type and a slight decrease in all other types, except the high FODMAPs type. Certain foods and dietary habits can be major factors exacerbating the symptoms of IBS and therefore require attention [3,30], Depending on the individual, it can prevent the recurrence of symptoms [31]. A study analyzing IBS severity and dietary habits in patients with IBS found that those who reported eating spicy foods more frequently had higher IBS-SSS than those who reported never eating spicy foods [32]. A study of food groups and foods that trigger symptoms in IBS patients in the Netherlands found that

https://doi.org/10.4163/jnh.2024.57.1.75

dairy was the fourth most common food group among eight food groups and a milk was the fourth most common single food among 36 single foods [33]. However, an intervention study that tried a low FODMAPs diet in patients with IBS showed a significant reduction in IBS-SSS, which is inconsistent with the results of this study [34], suggesting that the concept of a low FODMAPs diet in Korea may be more complex or difficult to implement than other food types. In addition to dairy products and fruits, high FODMAP foods, such as green onion and garlic, are commonly added as condiments to staple foods and side dishes in almost all Korean cuisines. This makes it challenging to completely avoid them or exclude them from the diet. We think that these results are partially reflected in the nutrient intake, and that educators and trainees should continue to make mutual efforts during nutrition counseling to ensure adequate nutrient intake for patients with IBS.

The limitations of this study are that it was limited to adults in their 20s and 30s, and it is difficult to generalize the results to patients with IBS, as it was conducted in symptomatic non-IBS according to Rome IV diagnostic criteria rather than in patients with pseudo-diagnosed IBS. Second, it was a single-arm study and could not be compared with a control group. The symptoms of IBS can be attributed to several individual factors. Nevertheless, it is significant that this study identified changes in the gut microbiota according to the main dietary factors that trigger symptoms and confirmed that dietary behavioral interventions through personalized nutrition education have the potential to improve the gut environment. Therefore, it is necessary to conduct follow-up studies on the improvement of symptoms due to changes in gut microbiota through continuous personalized nutritional intervention for people with IBS.

SUMMARY

This study evaluated the effectiveness of a 12-week web-based personalized nutrition management for 49 persons with IBS, aged 20–39 years, based on the types of foods that trigger IBS symptoms and evaluated the changes in gut microbiota. To evaluate the effectiveness of web-based personalized nutrition management, we analyzed changes in the distribution of gut microbiota, changes in the relative abundance of gut microbiota by foodtype, and changes in the IBS-SSS and FODMAPs intake by food type after providing personalized nutrition management according to the types of foods that trigger IBS symptoms. The relative abundance of gut microbiota changed after receiving personalized nutrition management according to the type of food that triggered IBS symptoms, and there was a significant decrease in *Veillonella.* In addition, when analyzing the diversity of gut microbiota according to the type of food that triggered symptoms, the diversity of gut microbiota increased significantly in the group that received personalized nutrition management of high FODMAPs type and FODMAPs-containing gluten type. These results confirm that web-based personalized nutrition management can significantly change the gut microbiota of IBS patients. Therefore, this study suggests that web-based personalized nutrition management may be helpful in alleviating the symptoms of people with IBS.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

General information about final study participants according to IBS symptoms trigger food type

https://doi.org/10.4163/jnh.2024.57.1.75

REFERENCES

1. Drossman DA. The functional gastrointestinal disorders and the Rome III process. Gastroenterology 2006; 130(5): 1377-1390. PUBMED | CROSSREF
2. Miwa H. Life style in persons with functional gastrointestinal disorders--large-scale internet survey of lifestyle in Japan. Neurogastroenterol Motil 2012; 24(5): 464-471. PUBMED | CROSSREF
3. Gibson PR, Shepherd SJ. Food choice as a key management strategy for functional gastrointestinal symptoms. Am J Gastroenterol 2012; 107(5): 657-666. PUBMED | CROSSREF
4. McKenzie YA, Bowyer RK, Leach H, Gulia P, Horobin J, O'Sullivan NA, et al. British Dietetic Association systematic review and evidence-based practice guidelines for the dietary management of irritable bowel syndrome in adults (2016 update). J Hum Nutr Diet 2016; 29(5): 549-575. PUBMED | CROSSREF
5. Buono JL, Carson RT, Flores NM. Health-related quality of life, work productivity, and indirect costs among patients with irritable bowel syndrome with diarrhea. Health Qual Life Outcomes 2017; 15(1): 35. PUBMED | CROSSREF
6. Rafferty AJ, Hall R, Johnston CS. A novel mobile app (Heali) for disease treatment in participants with irritable bowel syndrome: randomized controlled pilot trial. J Med Internet Res 2021; 23(3): e24134. PUBMED | CROSSREF
7. Singh RK, Chang HW, Yan D, Lee KM, Ucmak D, Wong K, et al. Influence of diet on the gut microbiome and implications for human health. J Transl Med 2017; 15(1): 73. PUBMED | CROSSREF
8. Bäckhed F, Ley RE, Sonnenburg JL, Peterson DA, Gordon JI. Host-bacterial mutualism in the human intestine. Science 2005; 307(5717): 1915-1920. PUBMED | CROSSREF
9. Topping DL, Clifton PM. Short-chain fatty acids and human colonic function: roles of resistant starch and nonstarch polysaccharides. Physiol Rev 2001; 81(3): 1031-1064. PUBMED | CROSSREF
10. Lee YK, Mazmanian SK. Has the microbiota played a critical role in the evolution of the adaptive immune system? Science 2010; 330(6012): 1768-1773. PUBMED | CROSSREF
11. Round JL, Mazmanian SK. The gut microbiota shapes intestinal immune responses during health and disease. Nat Rev Immunol 2009; 9(5): 313-323. PUBMED | CROSSREF
12. Drossman DA, Hasler WL. Rome IV-functional GI disorders: disorders of gut-brain interaction. Gastroenterology 2016; 150(6): 1257-1261. PUBMED | CROSSREF
13. Hwang S, Na W, Oh D, Sohn C. Development and evaluation of a web-based self-management program for Korean adult patients with irritable bowel syndrome based on the Information–Motivation–Behavioral skills model. Appl Sci 2023; 13(12): 6915. CROSSREF
14. O'Donnell LJ, Virjee J, Heaton KW. Detection of pseudodiarrhoea by simple clinical assessment of intestinal transit rate. BMJ 1990; 300(6722): 439-440. PUBMED | CROSSREF
15. Oh JY, Yang YJ, Kim BS, Kang JH. Validity and reliability of Korean version of International Physical Activity Questionnaire (IPAQ) short form. J Korean Acad Fam Med 2007; 28(7): 532-541.
16. Kim KN, Park JY, Shin TS, Jun KJ, Choi EY, Kim HJ, et al. Degree of stress and stress-related factors by the Korean version of the BEPSI. J Korean Acad Fam Med 1998; 19(7): 559-570.
17. Francis CY, Morris J, Whorwell PJ. The irritable bowel severity scoring system: a simple method of monitoring irritable bowel syndrome and its progress. Aliment Pharmacol Ther 1997; 11(2): 395-402. PUBMED | CROSSREF
18. Na W, Lee Y, Kim H, Kim YS, Sohn C. High-fat foods and FODMAPs containing gluten foods primarily contribute to symptoms of irritable bowel syndrome in Korean adults. Nutrients 2021; 13(4): 1308. PUBMED | CROSSREF
19. Lee HJ, Kim HJ, Kang EH, Jung KW, Myung SJ, Min YW, et al. Self-reported food intolerance in Korean patients with irritable bowel syndrome. J Neurogastroenterol Motil 2019; 25(2): 222-232. PUBMED | CROSSREF
20. Malinen E, Rinttilä T, Kajander K, Mättö J, Kassinen A, Krogius L, et al. Analysis of the fecal microbiota of irritable bowel syndrome patients and healthy controls with real-time PCR. Am J Gastroenterol 2005; 100(2): 373-382. PUBMED | CROSSREF
21. Shukla R, Ghoshal U, Dhole TN, Ghoshal UC. Fecal microbiota in patients with irritable bowel syndrome compared with healthy controls using real-time polymerase chain reaction: an evidence of dysbiosis. Dig Dis Sci 2015; 60(10): 2953-2962. PUBMED | CROSSREF
22. Zhuang X, Tian Z, Li L, Zeng Z, Chen M, Xiong L. Fecal microbiota alterations associated with diarrhea-predominant irritable bowel syndrome. Front Microbiol 2018; 9: 1600. PUBMED | CROSSREF

23. Treem WR, Ahsan N, Kastoff G, Hyams JS. Fecal short-chain fatty acids in patients with diarrhea-predominant irritable bowel syndrome: in vitro studies of carbohydrate fermentation. J Pediatr Gastroenterol Nutr 1996; 23(3): 280-286. PUBMED | CROSSREF

24. Tana C, Umesaki Y, Imaoka A, Handa T, Kanazawa M, Fukudo S. Altered profiles of intestinal microbiota and organic acids may be the origin of symptoms in irritable bowel syndrome. Neurogastroenterol Motil 2010; 22(5): 512-519. PUBMED

25. Zhu S, Liu S, Li H, Zhang Z, Zhang Q, Chen L, et al. Identification of gut microbiota and metabolites signature in patients with irritable bowel syndrome. Front Cell Infect Microbiol 2019; 9: 346. PUBMED | CROSSREF

26. Canani RB, Costanzo MD, Leone L, Pedata M, Meli R, Calignano A. Potential beneficial effects of butyrate in intestinal and extraintestinal diseases. World J Gastroenterol 2011; 17(12): 1519-1528. PUBMED | CROSSREF

27. Rangel I, Sundin J, Fuentes S, Repsilber D, de Vos WM, Brummer RJ. The relationship between faecal-associated and mucosal-associated microbiota in irritable bowel syndrome patients and healthy subjects. Aliment Pharmacol Ther 2015; 42(10): 1211-1221. PUBMED | CROSSREF

28. Jacobs JP, Lagishetty V, Hauer MC, Labus JS, Dong TS, Toma R, et al. Multi-omics profiles of the intestinal microbiome in irritable bowel syndrome and its bowel habit subtypes. Microbiome 2023; 11(1): 5. PUBMED | CROSSREF

29. Enck P, Mazurak N. Dysbiosis in functional bowel disorders. Ann Nutr Metab 2018; 72(4): 296-306. PUBMED | CROSSREF

30. Böhn L, Störsrud S, Törnblom H, Bengtsson U, Simrén M. Self-reported food-related gastrointestinal symptoms in IBS are common and associated with more severe symptoms and reduced quality of life. Am J Gastroenterol 2013; 108(5): 634-641. PUBMED | CROSSREF

31. Halpert A, Dalton CB, Palsson O, Morris C, Hu Y, Bangdiwala S, et al. What patients know about irritable bowel syndrome (IBS) and what they would like to know. National survey on patient educational needs in IBS and development and validation of the Patient Educational Needs Questionnaire (PEQ). Am J Gastroenterol 2007; 102(9): 1972-1982. PUBMED | CROSSREF

32. Back J, Jun SE. The relationship of eating habits and trigger foods to symptom severity of irritable bowel syndrome. J Korean Biol Nurs Sci 2015; 17(4): 297-305. CROSSREF

33. Rijnaarts I, Witteman BJM, Zoetendal EG, Govers C, de Wit NJW, de Roos NM. Subtypes and severity of irritable bowel syndrome are not related to patients' self-reported dietary triggers: results from an online survey in Dutch adults. J Acad Nutr Diet 2021; 121(9): 1750-1762.e8. PUBMED | CROSSREF

34. Schumann D, Langhorst J, Dobos G, Cramer H. Randomised clinical trial: yoga vs a low-FODMAP diet in patients with irritable bowel syndrome. Aliment Pharmacol Ther 2018; 47(2): 203-211. PUBMED | CROSSREF