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Research Article

An online low-FODMAP educational intervention improves physical and psychological symptoms of irritable bowel syndrome

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Abstract

The low fermentable oligo-, di- and monosaccharides, and polyols (FODMAPs) diet has proven beneficial for the management of irritable bowel syndrome (IBS). The growing demand and limited availability of registered dietitians specialized in IBS, together with the omnipresence of technology in daily life, provide an opportunity for the development of adapted resources. This study aimed to assess the impact of implementing the low FODMAP diet, through an online educational service platform, on the quality of life of patients living with IBS. A prospective single-group intervention pilot study involving patients with IBS from two hospitals was conducted. Participants followed the low-FODMAP diet using a web-based platform for 6 months. The IBS quality of life questionnaire (IBS-QoL), the IBS symptom severity scoring system (IBS-SSS), and the State-Trait Anxiety Inventory Form Y were completed at baseline, after the restriction phase and after reintroduction phase. Fifteen of the 35 recruited participants completed the study (80.0% female, median age of 43.0 (36.0–52.0) years) and at 6 months, a trend towards IBS-QoL improvement was observed, along with a significant improvement in IBS-SSS (from 276 to 200; $p < 0.05$) and state anxiety level (from 44 to 33; $p < 0.05$). The results of this pilot study provide valuable insights for the design of a larger study, with promising relevance and utility of teaching the low-FODMAP diet using alternative educational methods.

Key words: low fodmap diet, irritable bowel syndrome, online intervention, web-based platform, nutritional education strategy, quality of life

Introduction

Irritable bowel syndrome (IBS) is a disorder of gut-brain interaction characterized by abdominal pain and change in bowel habits (Ford et al. 2020). It is the most common gastrointestinal condition, affecting 9% of the worldwide population (Oka et al. 2020), and 11% of Canadians (Sperber et al. 2021). Risk factors include previous gastroenteritis, female sex, young age, anxiety, depression, stress, frequent use of healthcare services as well as pain and sleep disorders (Creed 2019). Despite its widespread occurrence, the pathophysiology of IBS is not completely understood. Intestinal dysmotility, visceral hypersensitivity, and psychosocial disturbances have been identified as potential traditional mechanisms underlying its development (Videlock and Chang 2021). The most common symptoms include diarrhea, constipation, bloating, and abdominal discomfort or pain (Ford et al. 2020). Mental health problems, such as anxiety, depression, and excessive fear of illness, also often co-occur with IBS (Staudacher et al. 2021), significantly affecting quality of life (QoL).

The management of IBS relies on the improvement of symptoms and QoL through pharmacological, psychological and nutritional care. Among nutritional therapies, the low fermentable oligo-, di- and monosaccharides, and polyols (FODMAP) diet is of clinical interest (Gibson and Shepherd 2005). This diet reduces foods rich in short-chain carbohydrates and sugar alcohols, namely fructans, galactans, lactose, fructose in excess of glucose, isomalt, maltitol, mannitol, sorbitol, and xylitol, since these poorly absorbed carbohydrates increase intestinal osmolarity and fermentation in the colon, exacerbating IBS symptoms (Gibson and Shepherd 2005; Staudacher and Whelan 2017). The low-FODMAP diet aims to test individual tolerance to these subgroups through three phases, i.e., restriction, reintroduction, and personalization (Sultan et al. 2022). The restriction phase encourages a strict restriction of FODMAPs. If a marked reduction in gastrointestinal symptoms is observed, patients are considered as responder and can proceed to the reintroduction phase. In this phase, each category of FODMAP are tested for tolerance, based on the severity of gastrointestinal symptoms. The

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increase occurs incrementally to determine tolerance. If tolerated, foods rich in FODMAP are gradually reintroduced. The personalization and long-term phase is dedicated to the adaptation of the diet according to individuals' tolerance, which is the ultimate goal of the FODMAP protocol (Whelan et al. 2018).

An innovative approach was developed by the SOSCuisine® platform (SOSCuisine 2005), an online menu service adapted to different conditions, including IBS. It enables people living with IBS to follow the FODMAP protocol (Monash University 2019) in a self-service context, using online resources of personalized weekly low-FODMAP menus, instructions for each phase, and a peer support group moderated by a specialized registered dietitian (RD). The primary objective of this project was to evaluate the impact of following the low-FODMAP diet through the SOSCuisine® platform including a support group on the QoL of patients living with IBS. Measuring QoL provides a comprehensive assessment of the effect of the online nutritional strategy in these patients. The effect of the dietary educational intervention on IBS symptom severity, anxiety, and dietary intake were evaluated as secondary objectives. Given the pilot nature of the study, retention, adherence, and satisfaction of participants were also assessed to further guide the elaboration of a full-scale study.

Materials and methods

Study design and population

This prospective single-group intervention pilot study included males and females living with IBS followed at the gastroenterology clinics of the *Centre Hospitalier de l'Université de Montréal* (CHUM) or the *Hôpital Maisonneuve-Rosemont* in Montreal, Canada, from May 2020 to September 2021. The study was introduced to the patients by the gastroenterologist during a clinical appointment. If patients expressed interest, their contact information was shared with the research team, who then reached out by phone to provide further details about the study.

To be eligible, participants had to be 18 years of age or older and have a diagnosis of IBS according to the Rome IV criteria (Lacy et al. 2016) by a gastroenterologist within the past three months. Patients had to understand French, have an Internet access and a Facebook© account with a self-reported familiarity to use them. Considering the restrictive nature of the low-FODMAP diet, patients suffering from a known eating or mental health disorder, or patient displaying a body mass index under 18.5 kg/m^2 were not eligible. Additionally, individuals with type 1 or 2 diabetes, pregnancy, or other chronic gastrointestinal diseases, except gastroesophageal reflux, were not eligible, as the effects of the diet have not been evaluated in these populations. The study was conducted in accordance with the Declaration of Helsinki and approved by the CHUM Research Ethics Committee (#19-304). No financial compensation was provided for participation. Written informed consent was obtained from participants prior to enrolment.

The estimated minimum sample size was 30 participants, based on other studies on the low-FODMAP diet in IBS patients (Pedersen 2014; Bellini et al. 2017; McIntosh et al. 2017; Paduano et al. 2019). To account for a conservative 30% attrition rate, we planned to recruit 40 participants.

Setting of the web platform

Participants were invited to follow the online low-FODMAP diet offered by SOSCuisine®, characterized by three specific features. First, participants received customized weekly low-FODMAP menus based on the Monash University protocol (Monash University 2019). Second, a virtual assistant accompanied participants from the beginning to the end of the diet implementation, providing personalized recommendations tailored to individual's food preferences and intensity of symptoms. The assistant delivered information through short videos lasting four minutes each and totalizing 70 min, and text-resources including a comprehensive guide for each phase, 100 articles on integrating the low-FODMAP diet into daily life and answers to 50 frequently asked questions. During the restriction phase, the assistant provided detailed instructions, including criteria for progressing to the next phase and lists of high- and low-FODMAP foods. For the reintroduction phase, the assistant guided individuals through the process of testing specific FODMAP subgroups, offering food suggestions based on individual preferences, and portion sizes. The algorithm adapted to participants' needs, recommending portion sizes for each test based on the food selected and the intensity of symptoms experienced during previous tests. For the personalization phase, a table summarizing the quantities of FODMAP-rich foods based on tolerance experienced during the reintroduction phase was provided. The last feature of the platform was the access to a peer support group on Facebook©, designed to foster communication among participants. This group allowed individuals to ask questions and receive valid answers, as the group was moderated by a FODMAP-specialized RD.

Outcome measures

The primary outcome was the change in QoL from baseline to the end of study, assessed by the validated IBS-QoL questionnaire (Patrick et al. 1998; Drossman et al. 2000). This questionnaire assesses 8 domains, namely dysphoria, interference with activity, body image, health worry, food avoidance, social reaction, sexual concerns and relationships, from which a computed score is drawn. This score, ranging from 0 to 100, was developed to assess the self-reported QoL in IBS, a higher score indicating a better QoL.

Secondary outcomes included changes in severity of IBS symptoms, measured by the validated IBS-Severity Scoring System (IBS-SSS) (Francis et al. 1997). This questionnaire evaluates 5 specific domains within the last ten days: abdominal pain severity, abdominal pain duration, abdominal distension, bowel habits dissatisfaction and interference with life. A composite score is calculated and varies from 0 to 500. Depending on the score, the severity can be classified in four categories: absence of symptoms severity or remission (score < 75), mild (score 75–174), moderate (score 175–299), and severe (score $\geq$300).

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Anxiety was evaluated by the French-Canadian adaptation of the State-Trait Anxiety Inventory Form Y (STAI) (Spielberger 1983; Gauthier and Bouchard 1993), which specifically assesses state anxiety (STAI-S), the subjective and transient emotional state of anxiety, and trait anxiety (STAI-T), a more stable predisposition to anxiety. The STAI-S score can be classified in five categories: very low state anxiety (score < 36), low (score 36–45), moderate (score 46–55), high (score 56–65), and very high (score >65) (Bauer et al. 2016). For the STAI-T score, a score inferior to 40 commonly indicates low trait anxiety while a score of 40 or more indicates high trait anxiety (Kose et al. 2021).

Finally, dietary intake was assessed using a validated, web-based, self-administered 24 h dietary recall (R24W) developed at *Université Laval* (Jacques et al. 2016; Lafrenière et al. 2017, 2018).

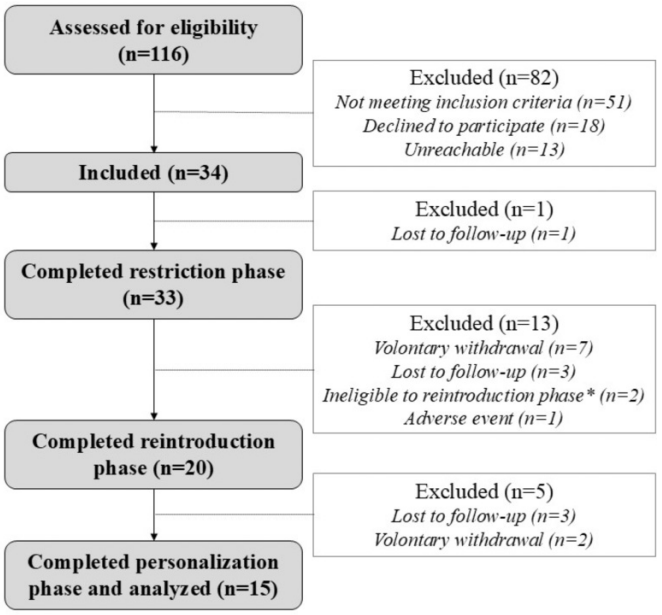
Data collection

Data were collected through online questionnaires at three timepoints (T1, T2, and T3) over the 6-month follow-up. T1 data collection occurred within 2 weeks prior to diet initiation and included sociodemographic and lifestyle assessments as well as questionnaires measuring QoL, IBS symptom severity, and anxiety. Participants were invited to complete the same three questionnaires at the end of the restriction phase (T2), which lasted three to 8 weeks, and after the reintroduction phase (T3), lasting 8–12 weeks.

Nutritional data was collected at each timepoint where participants were invited by e-mail to complete the R24W on 2 unannounced days (1 weekend day and 1 weekday) selected randomly by a computer algorithm over a 7-day period. Intake of specific FODMAP, namely lactose, fructose in excess of glucose, sorbitol, and mannitol, were measured to assess diet compliance at each phase. In addition, diet adherence was evaluated at T3 by a French version translated by the research team of the FODMAP Adherence Report Scale (FARS) (Maagaard et al. 2016). This 25-point questionnaire measured adherence to the adapted diet according to the individual's tolerance experienced during the previous phases. A total score of at least 20 points (≥80%) was considered as adherence to the diet. The usage metrics, i.e., frequency of connexion and pages visited, were indicators of engagement with the web platform. Adherence to the support group was assessed at T3 with three questions assessing frequency of visits and actions carried out on the group.

Satisfaction to four specific aspects of the web platform, namely satisfaction to the global web platform, suggested recipes, educational content, and availability of food on the market, was assessed at T3 using a 5-point Likert scale. At T1 and T3, the use of medication for IBS symptoms relief and other nutritional educational resources were collected as potential confounding variables by specific questions developed by the research team. Furthermore, phone calls were conducted every 2 weeks by the graduate student (also a RD) in charge of the study to monitor the occurrence of adverse events, verify the progression on the platform and the completion of the dietary recalls, and answer participants' questions.

Fig. 1. Flow diagram of participants. *Due to lack of improvement in symptoms after restriction phase.



*Due to lack of improvement in symptoms after restriction phase.

Statistical analysis

Data were tested for normality using the Shapiro–Wilk test and were expressed as median (interquartile range) for continuous variables and number (percentage) for categorical variables. Differences between timepoint measures were tested using Friedman's repeated-measures ANOVA analysis, and Kendall's concordance test, both tests adjusted by Bonferroni's correction. Data from lost to follow-up participants were not included in the analysis. The statistical significance level was set at $p < 0.05$, and analyses were performed with SPSS (version 27, IBM).

Results

116 patients were assessed for eligibility, and of these, 34 were included and 15 completed the study (Fig. 1). Those who did not completed the study either asked to withdraw ($n = 9$), were lost to follow-up ($n = 7$), or were withdrawn for other reasons, i.e., not eligible to reintroduction phase due to lack of improvement in symptoms after restriction phase ($n = 2$) or adverse event ($n = 1$).

Baseline demographic and clinical characteristics of participants who completed the study are presented in Table 1. The majority of participants were female ($n = 12$, 80.0%), with an ethnic origin from North America ($n = 13$, 86.7%), and a median age of 43.0 (36.0–52.0) years. Most participants were highly educated, with 11 (73.3%) holding a post-secondary degree. The majority of participants had experienced their first gastro-intestinal symptoms more than 5 years ago ($n = 10$, 66.7%), although their IBS medical diagnosis was relatively recent i.e., 0.2 (0.0–3.0) years. In the last 3 months, 8 (53.3%) participants reported using resources other than a physician to

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Table 1. Baseline characteristics of participants.

Characteristic	Participants ($n = 15$)
Sex, female	12 (80.0)
Age, years	43.0 (36.0–52.0)
Ethnic origin	
North American	13 (86.7)
European	2 (13.3)
Highest education degree	
Primary school diploma	2 (13.3)
High school diploma	2 (13.3)
College diploma or certificate	4 (26.7)
University diploma	7 (46.7)
Body mass index, kg/m^2	24.5 (21.5–29.7)
Time since first gastro-intestinal symptoms	
3 to 12 months	3 (20.0)
1 to 5 years	2 (13.3)
More than 5 years	10 (66.7)
Time since IBS medical diagnosis, years	0.2 (0.0–3.0)
Used resources other than physician in the last 3 months to help reduce symptoms	8 (53.3)
Website	5 (29.4)
Book	2 (11.8)
Mobile application	1 (5.9)
Other[a]	2 (11.8)
Used medication in the last 3 months to reduce symptoms	9 (60.0)
Antispasmodic	6 (66.7)
Laxative	4 (44.4)
Other[b]	3 (33.3)
Previously tried to follow a low-FODMAP diet	6 (40.0)
In the last year	2 (13.3)
1–3 years ago	3 (20.0)
More than 5 years ago	1 (6.7)

Note: Categorical variables described as *n* (%), continuous variables described as median (IQR). FODMAP, Fermentable Oligo-, Di- and Monosaccharides, and Polyol.
[a]Other resources included naturopath ($n = 1$) and osteopath ($n = 1$).
[b]Other medication included guanylate cyclase-C agonist ($n = 2$), and antiflatulent ($n = 1$).

help them reduce their symptoms, including website ($n = 5$, 29.4%), book ($n = 2$, 11.8%), mobile application ($n = 1$, 5.9%), or other resource such as naturopath or osteopath ($n = 2$, 11.8%). Nine (60.0%) participants also reported using medication in the past 3 months for symptoms relief, such as antispasmodic ($n = 6$, 66.7%), laxative ($n = 4$, 44.4%), or other medication such as guanylate cyclase-C agonist or antiflatulent ($n = 3$, 33.3%). Lastly, 6 (40.0%) participants had previously tried to follow a low-FODMAP diet, either with the help of a physician ($n = 2$), dietitian ($n = 2$), or by consulting website ($n = 2$) or book ($n = 2$).

Quality of life, IBS symptom severity, and anxiety scores

Evolution of QoL, assessed by the IBS-QoL questionnaire, symptom severity, evaluated by the IBS-SSS, and anxiety, assessed by the STAI questionnaire, are presented in Fig. 2. For QoL, the total score varied from 66.9 (36.8–72.8), 56.6 (47.8–77.2), and 71.3 (60.3–79.4) at T1, T2, and T3, respectively. The difference between scores across the three timepoints did not reach statistical significance ($p = 0.057$) (Fig. 2A). All QoL subscores decreased after the restriction phase, except for body image (all non-significant compared to baseline), and increased after the reintroduction phase. Only dysphoria subscore significantly improved at the end of study compared to baseline ($p = 0.014$) (Fig. 2B).

For IBS symptom severity, the total score varied from 276 (225–361), 150 (124–270), and 200 (140–250) at T1, T2, and T3, respectively. The improvement in score from baseline to study completion was statistically significant ($p = 0.01$), as well as for the improvement after the end of the restriction phase ($p = 0.001$) (Fig. 2C). Accordingly, improvement in three specific subscores was observed i.e., abdominal pain duration (T1 vs. T3; $p = 0.024$, and T1 vs. T2; $p = 0.002$), abdominal distension (T1 vs. T2; $p = 0.024$) and interference with life in general (T1 vs. T3, $p = 0.004$) (Fig. 2D). Furthermore, the proportion of participants in each of the IBS-SSS categories (re-

Fig. 2. Comparison of quality of life, symptom severity and anxiety scores across the three timepoints measures. (A) IBS-QoL total score's evolution for each participant; (B) median (IQR) IBS-QoL subscores for each timepoint; (C) IBS-SSS total score's evoluation for each participant; (D) median (IQR) IBS-SSS subscores for each timepoint; (E) proportion of participants according to IBS-SSS categories for each timepoint; (F) STAI-S score's evolution for each participant; (G) proportion of participants according to STAI-S categories for each timepoint; (H) STAI-T score's evolution for each participant. $^{*}p < 0.05$. IBS-QoL: Irritable Bowel Syndrome-Quality of Life; IBS-SSS: Irritable Bowel Syndrome-Symptom Severity Scale; STAI-S: State-Trait Anxiety Inventory-State; STAI-T: State-Trait Anxiety Inventory-Trait.

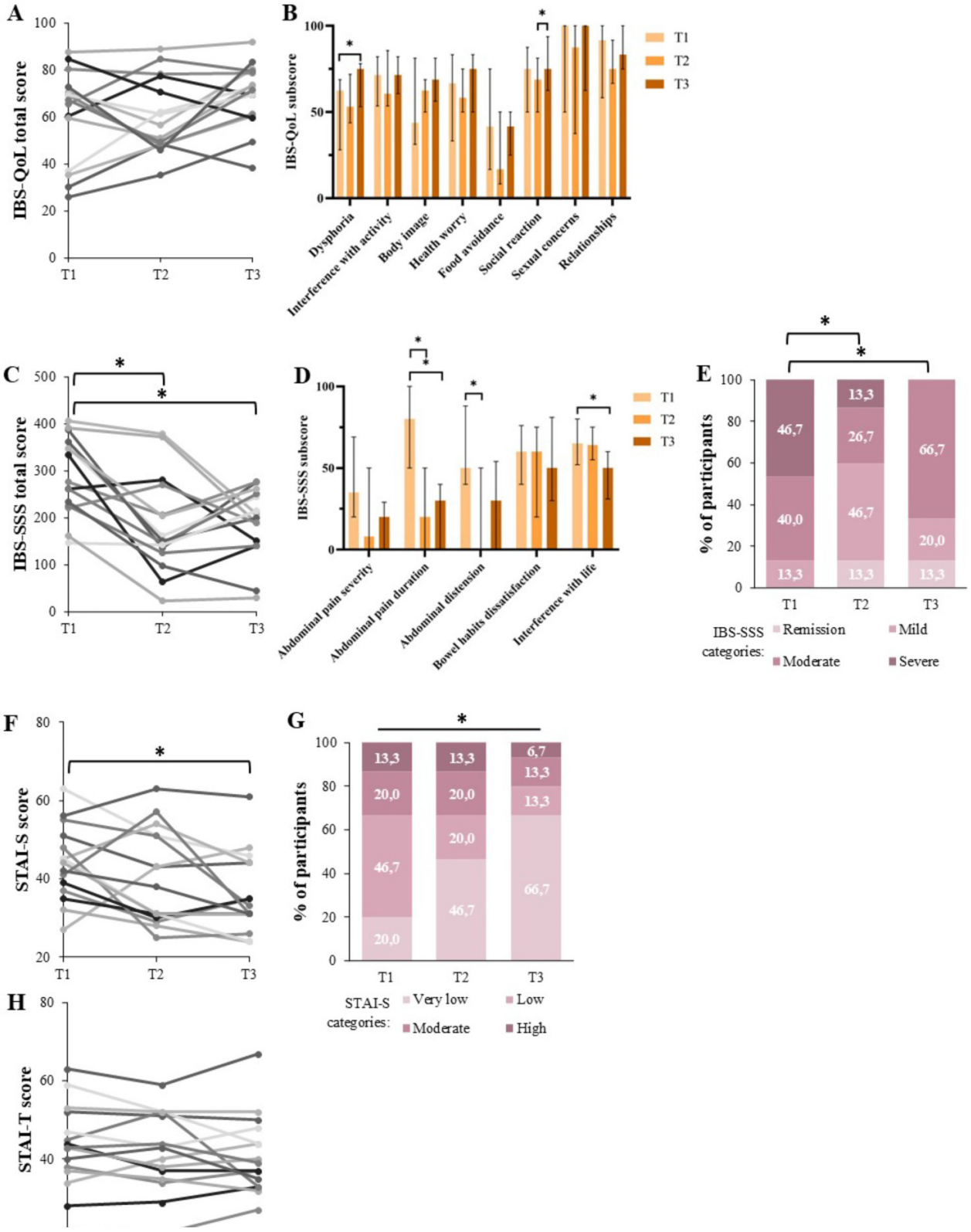

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Table 2. Comparison of daily dietary intake across the three timepoints measures.

Nutrient	T1	T2	T3	*p*-value
Energy, kcal	1742.0 (1631.5–2197.0)	1553.0 (1263.0–2267.0)	1691.5 (1365.0–2062.0)	0.074
Fat, g	82.2 (70.3–101.5)	67.7 (53.3–90.5)[b]	73.4 (55.4–106.8)	0.022
% energy	40.3 (36.8–45.9)	38.7 (35.9–41.8)	38.9 (34.7–46.0)	0.936
Protein, g	69.7 (62.6–87.8)	77.3 (60.9–84.0)	66.6 (57.8–77.8)	0.344
% energy	15.5 (14.2–18.1)	19.2 (14.8–20.4)	16.6 (14.4–18.5)	0.262
Total carbohydrate, g	183.4 (141.2–247.5)	159.1 (130.7–183.0)	148.8 (115.0–221.4)	0.057
% energy	38.6 (32.6–43.8)	37.0 (34.1–42.2)	40.2 (30.0–47.0)	0.936
Fructose, g	6.27 (4.35–21.24)	9.58 (4.57–12.90)	7.55 (3.44–9.73)	1.000
Glucose, g	6.48 (4.05–15.31)	11.68 (4.60–15.82)	7.70 (3.58–10.71)	0.420
Excess fructose[a], g	0.44 (0.00–3.87)	0.00 (0.00–0.18)	0.43 (0.00–1.03)	0.867
Lactose, g	6.52 (0.34–14.5)	2.06 (0.47–3.59)	1.70 (0.53–5.43)	0.766
Sorbitol, g	0.03 (0.00–0.48)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.007
Mannitol, g	0.04 (0.00–0.08)	0.04 (0.02–0.07)	0.04 (0.01–0.08)	0.571
Dietary fiber, g	18.1 (15.0–21.0)	16.5 (10.6–18.4)	12.9 (11.4–18.8)	0.165

Note: Values expressed as median (IQR).
[a]Excess fructose = fructose—glucose. When glucose intake exceeded fructose intake, a value of 0 was indicated.
[b]$p = 0.019$ for difference between T1 and T2.

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mission, mild, moderate, severe) significantly changed over time ($p = 0.002$). While 7 (46.7%) participants displayed severe symptoms at T1, this proportion decreased to 2 (13.3%) at T2, and to none at T3. Conversely, no participant presented an absence of symptoms severity, based on the IBS-SSS score at baseline, but by T2 and T3, this proportion increased to 2 (13.3%) participants (Fig. 2E).

State anxiety, assessed by the STAI-S score, decreased from 44 (37–51) to 38 (30–51) and 33 (31–44) at T1, T2, and T3, respectively. A significant improvement was observed between baseline and end of study ($p = 0.01$) (Fig. 2F). Additionally, the proportion of participants in each of the STAI-S categories (very low, low, moderate, high) significantly changed over time ($p = 0.016$). While 3 (20.0%) participants displayed very low state anxiety at T1, this proportion increased to 7 (46.7%) at T2 and to 10 (66.7%) at T3 (Fig. 2G). For trait anxiety, assessed by the STAI-T score, the score varied from 43 (37–52), 43 (37–52), and 39 (33–48) at T1, T2, and T3, respectively. The difference between scores across the three timepoints was not significant (Fig. 2H). Regarding score categories, 10 (66.7%) participants displayed high trait anxiety at baseline while 5 (33.3%) had low trait anxiety. No significant change was found in the proportion of participants in each category over time.

Dietary intake

Daily dietary intakes of participants are presented in Table 2. Reductions in specific FODMAP intakes, i.e., lactose, sorbitol, and excess fructose, were observed after the restriction phase, however not reaching statistical significance. Significant reduction in fat intake was observed at the end of the restriction phase (82.2 g (70.3–101.5) to 67.7 g (53.3–90.5); $p = 0.019$), followed by an increase to 73.4 g (55.4–106.8) by the end of study. No significant changes were observed in energy, protein, carbohydrate, or fiber intake across the three timepoints.

Adherence, satisfaction, and safety

Regarding adherence to the diet, measured by the FARS questionnaire at the end of study, participants displayed a median score of 21.0 (19.0–23.0) on a possible total point of 25. Based on this questionnaire, 11 (73.3%) participants were compliant, meaning they were following a modified low-FODMAP diet according to their tolerance experienced during the previous phases. The usage metrics, recorded to assess engagement with the web platform, showed that each participant consulted the recipe pages 230.0 (111.0–434.0) times during the restriction phase, and 44.0 (17.0–195.0) times during the reintroduction phase. The frequency of visits to the personalized menus for the restriction and reintroduction phases was 64.0 (41.0–188.0) and 25.0 (14.0–90.0) times, respectively. For engagement with the peer support group, 2 (13.4%) participants reported visiting the Facebook© group page three times or more per week, 5 (33.3%) participants consulted it one to three times a week, and 8 (53.3%) participants visited it less than once a week. Actions carried out on the group included viewing publications and comments by members ($n = 11$, 36.7%), posting questions or comments ($n = 10$, 33.3%), and interacting with the RD ($n = 7$, 23.3%) or with members ($n = 2$, 6.7%). For the use of other resources related to the low-FODMAP diet i.e., websites, books, and mobile applications, the proportion of participants reporting their use remained the same at baseline and the end of the study ($n = 8$, 53.3%). Regarding the use of medication for IBS symptoms relief, the majority ($n = 12$, 80.0%) of participants were not prescribed new medication during the study.

Participants' satisfaction of the SOSCuisine® platform was assessed at the end of study by 4 questions addressing their satisfaction with the global web platform, the educational content, the suggested recipes and the availability of food on the market (Fig. 3). Regarding the global web platform's satisfaction, 14 (93.3%) participants were satisfied at various levels, while 1 (6.7%) participant was not very satisfied (Fig. 3A). For the suggested recipes, 11 (73.3%) participants were

Fig. 3. Participants' satisfaction of the SOSCuisine® web platform.

satisfied at various levels, while 4 (26.7%) participants were not very satisfied or not satisfied at all (Fig. 3B). All participants were satisfied at various levels with the educational content proposed by the platform and the availability of food proposed on the market (Figs. 3C and 3D).

Four unexpected non-serious adverse events occurred during the study due to severe weight loss ($n = 2$) or headaches and fatigue that may have been related to reduced dietary intake ($n = 2$). These participants were closely monitored by the gastroenterologist and the clinical research team to ensure adequate care. After resolution, they were allowed to continue the study, except for one participant whose adverse event was deemed severe and was withdrawn for safety reasons.

Discussion

To our knowledge, this is the first study to evaluate the impact of a low-FODMAP self-service web platform, including a support group, on physical and psychological symptoms of patients living with IBS. The dietary intervention was well accepted with great adherence and did not lead to nutritional deficiencies. The main findings demonstrated significant improvements in IBS symptom severity and anxiety with a trend towards QoL improvement. Even though the small sample size calls for caution with the interpretation of the results, this pilot study provides promising results with valuable new insights therefore meriting a larger clinical study design.

Participants exhibited a 6.6% improvement in QoL by the end of study, although not statistically significant compared to baseline. A difference in QoL would have been expected, given the improvements in symptom severity and anxiety, both of which are known to be associated with QoL in IBS (Drossman et al. 2000). However, the absence of a statistically significant difference between timepoints may also be due to the small sample size, which limited the statistical power of the analysis. A study in 25 patients with IBS compared the use of low-FODMAP diet educational materials on a website with or without access to a mobile food application and revealed that the combined use of methods led to a further improvement in QoL (Rafferty et al. 2021). In 459 patients with IBS, the use of a FODMAP-lowering diet mobile application or a spasmolytic agent led to significant improvements in QoL in both groups (Carbone et al. 2022). In our study, the insignificant improvement in the IBS-QoL total score included the dysphoria subscore, defined as "a mood characterized by generalized discontent and agitation" (American Psychological Association 2018), which significantly improved by the end of study. This suggests that participants experienced less dissatisfaction related to their condition after following the FODMAP protocol. Although studies examining the impact of technology-based approaches to teaching the low-FODMAP diet on QoL remain limited, the literature suggests favourable changes in patients with IBS. This is especially important, as IBS has a profound negative impact on patients' well-being and QoL (Cassar et al. 2020), highlighting the need for further investigation in larger studies.

The low-FODMAP approach resulted in a 50% and a 33% reduction in symptom severity following the restriction phase and end of the study, respectively. Importantly, for 11 (73.3%) participants, the improvement in symptom severity was considered clinically significant with an increase in IBS-SSS by at least 50 points as previously defined (Francis et al. 1997). More specifically, two subscores heavily influenced the symptom severity; reduction in abdominal pain duration and decreased interference with daily life. In a recent study with 228 participants, pre-recorded dietitian-led webinars for teaching the FODMAP restriction phase led to a 50.9% reduction in IBS symptoms (Colgan et al. 2024). In another study involving 21 462 users of a low-FODMAP diet mobile application across all 3 diet phases found significant self-reported improvement in gastrointestinal symptoms (Dimidi et al. 2023), suggesting that the low-FODMAP approach delivered through technology can also improve physical well-being.

State anxiety was reduced by 25% at the end of the study compared to baseline while trait anxiety levels did not change, possibly because the diet intervention was more effective at modulating state anxiety, which refers to transient emotional state, rather than the anxiety personality trait, which is a long-standing component of anxiety (Spielberger 1983). It is plausible that the improvement in symptom severity could have contributed to the reduction in the participants' anxiety, given the bidirectional relationship between gastrointestinal symptoms and mental health comorbidities,

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such as anxiety (Staudacher et al. 2023). However, in a recent meta-analysis that included five studies (377 participants with IBS), the low-FODMAP diet did not significantly impact anxiety when compared to other treatments (Khalighi Sikaroudi et al. 2024). In those studies, anxiety was measured using the Hospital Anxiety and Depression Scale, while we used the STAI questionnaire in our study, which limits direct comparison of results.

Concerns have been raised about the nutritional adequacy of the low-FODMAP diet given its restrictive nature (Bellini et al. 2020). However, the present dietary approach did not result in nutritional deficiencies, as participants' intake in energy and macronutrients remained stable throughout the study. A slight decrease in lipid consumption was observed at the end of the restriction phase but increased after the reintroduction phase. This underlines the importance of undertaking all 3 phases of the FODMAP protocol and not extending the restrictive phase beyond the recommended duration to avoid the onset of nutritional deficiencies (Lacy et al. 2021).

Dietary intake is also an indicator of participants' adherence to the diet. During the restriction phase when FODMAPs were eliminated, a decrease in lactose, sorbitol, and excess fructose intake was observed, although not reaching statistical significance. When FODMAPs were gradually reintroduced based on individual tolerance, intake of specific FODMAP increased, as observed by excess fructose intake. Overall, the results provide only a partial view of diet adherence, as the dietary recall tool was not tailored to measure intake of all FODMAP categories. This analysis could have been strengthened with the use of a food frequency questionnaire specifically measuring FODMAP intake (Barrett and Gibson 2010). Nevertheless, the FARS questionnaire was used to assess diet adherence in a more comprehensive manner. Based on the results, 11 (73.3%) participants were adherent, meaning they reported that they followed a modified low-FODMAP diet according to their tolerance at the end of study, which is the ultimate goal of the FODMAP protocol. The FARS median score of 21.0 is similar to what has been observed using the IBS Constant Care mobile application for monitoring of the low-FODMAP diet. In 21 patients with IBS, a FARS score of 21.1 was found in 8 participants who completed the reintroduction phase (Ankersen et al. 2021). Therefore, together with our results, this demonstrates that while attrition rates were high, participants who completed the intervention showed strong adherence.

In terms of participants' engagement with the web platform, the usage metrics indicated that the recipe page was frequently consulted, especially during the restriction phase. This is an important feature of the platform as it proposes tangible resources for preparing meals in line with the low-FODMAP diet, which may have contributed to participants' sense of empowerment in achieving the dietary changes (Chen et al. 2017). Regarding engagement with the support group, participants not only visited the page but also carried out actions with the group, including posting questions or comments and interacting with the RD or participants. The support group seemed to facilitate interactions among individuals undergoing similar dietary changes, and provide easier access to reliable source of information from the RD. We believe this is a strength of the SOSCuisine® approach.

Satisfaction is known to be a key factor in promoting adherence (Barbosa et al. 2012). We evaluated satisfaction via the global web platform, the educational content, the suggested recipes and the availability of food on the market. Overall, the participants expressed overall positive satisfaction across these parameters. The suggested recipes appeared to be the least appreciated by some participants. Consistent with this, two participants discontinued their participation because they felt the nutritional intervention did not align with their cultural food habits or allergy restrictions. This highlights an aspect that could have been more thoroughly addressed with a more ethnoculturally diverse participant sample. Moving forward, the recipe selection should be more inclusive, catering to a broader range of dietary needs and considering cultural differences.

Some adverse events were reported during the study, including severe weight loss or headache and fatigue that may have been related to reduced dietary intake. Although participants could ask questions and share their concerns on the Facebook© group moderated by the RD, they could have benefited from individualized monitoring from the RD. In fact, two participants ended their participation because they felt they needed a more personalized follow-up.

Regarding potential confounding variables, baseline results showed that participants actively sought resources to alleviate their symptoms ($n = 8$, 53.3%), including 6 (40.0%) participants who had already tried the follow the low-FODMAP diet. However, doubts remain about the reliability of the resources consulted (websites, books, mobile applications), as none on the participants reported seeking advice from a RD. This adds to the relevance of an evidence-based platform, such as the one used in the present study, supported by a specialized RD. The proportion of participants reporting the use of other resources related to the low-FODMAP diet remained unchanged from baseline to the end of the study ($n = 8$, 53.3%). As for medication use for IBS symptoms relief, the majority ($n = 12$, 80.0%) of participants did not use new medication during the study, suggesting the beneficial effects were primarily due to the low-FODMAP diet intervention.

The self-service method proposed by the SOSCuisine® web platform is a unique and innovative approach, which is an undeniable strength of this study. Other strengths include the implementation of the three phases of the FODMAP protocol, as recommended by clinical guidelines (Lacy et al. 2021), as well as the use of validated questionnaires specific to the target population. Although the role of the RD should be reevaluated to ensure a more central position, the presence of a specialized RD is another important strength of the study. However, some limitations call for caution in results interpretation. First, selection bias may have been introduced due to restricted eligibility criteria, as 51/116 (44%) potential participants were deemed ineligible. As this limits the generalizability of the findings, broader selection criteria to include a more diversity of individuals should be considered in further studies. Second, the small sample size and low retention rate reduced the statistical power of the analysis, and prevented more in-depth statistical analysis, such as multi-

variate analysis. The most common cause for drop-out was voluntary withdrawal (9/19 participants, 47.4%), and reasons of withdrawal were identified as opportunities for improvement while planning a full-scale study, such as enhancing the role of the RD within the support group (not only acting as a moderator but also providing one-to-one support when necessary), and considering cultural food diversity and individual dietary restrictions when proposing recipes. Third, the absence of a control group limits the ability to establish causal inferences, and given the chronic and remitting nature of IBS, the natural symptom variation over time was not accounted for. Furthermore, self-reported outcomes may have been influenced by recall and desirability bias. Finally, the study was conducted during the COVID-19 pandemic, one of the most significant global health crises in recent history, which may have impacted participants' QoL and anxiety levels (Graff et al. 2021). Considering these limitations, improvements can be achieved to develop a larger study to conclude the beneficial effect of low-FODMAP diet.

In conclusion, following the low-FODMAP menus through the SOSCuisine® online service demonstrated an improvement in IBS symptom severity and anxiety from which patients suffer from living with IBS, even though QoL did not significantly improve. There is still a growing demand, with limited availability of RDs with appropriate expertise, to teach the low-FODMAP diet. The omnipresence of technology in the daily life of individuals and the complexity of this diet justifies the development of adapted resources (Ankersen et al. 2017). The innovative approach developed by SOSCuisine® has the potential to facilitate and democratize IBS management for patients seeking to follow the low-FODMAP diet but lacking support from trained professionals, while ensuring the access to a rigorous, science-based protocol. This study provides new insights into the potentially beneficial effects of low-FODMAD diet intervention, and these preliminary results will help guide future studies.

Take-home message

An online low-FODMAP diet education platform improved symptom severity and anxiety in patients with IBS. These preliminary findings provide promising relevance for teaching the low-FODMAP diet using alternative methods.

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Data availability

Data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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