Ther Adv Gastroenterol
2018, Vol. 11: 1–11
DOI: 10.1177/1756283X17746625

Food consumption and dietary intakes in 36,448 adults and their association with irritable bowel syndrome: Nutrinet-Santé study

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Abstract

Introduction: Diet plays an important role for patients with irritable bowel syndrome (IBS). The aim of this study was to compare the diets in terms of food consumption and nutrient intake between subjects with IBS and controls in a large French population.

Methods: This study included 36,448 subjects from the Nutrinet-Santé cohort study, who completed a questionnaire pertaining to functional bowel disorders based on the Rome III criteria. Dietary data were obtained from at least three self-administered 24 h records *via* the internet. Association between IBS and diet was evaluated by comparison tests controlled for gender, age and total energy intake (ANCOVA tests).

Results: Subjects included were mainly women (76.9%) and the mean age was 50.2 ± 14.2 years. Among these individuals, 1870 (5.1%) presented with IBS. Compared to healthy controls, they had significantly lower consumption of milk (74.6 *versus* 88.4 g/day; $p < 0.0001$), yogurt (108.4 *versus* 115.5 g/day; $p = 0.001$), fruits (192.3 *versus* 203.8 g/day; $p < 0.001$), and higher soft non-sugared beverages (1167.2 *versus* 1122.9 ml/day; $p < 0.001$). They had higher total energy intake (2028.9 *versus* 1995.7 kcal/day; $p < 0.001$), with higher intakes of lipids (38.5 *versus* 38.1% of total energy intake; $p = 0.001$) and lower intakes of proteins (16.4 *versus* 16.8% of total energy intake; $p < 0.0001$), as well as micronutrients (calcium, potassium, zinc and vitamins B2, B5 and B9, all $p < 0.0001$).

Conclusions: In this large sample, these findings suggest that dietary intake of subjects suffering from IBS differs from that of control subjects. They may have adapted their diet according to symptoms following medical or non-medical recommendations.

Keywords: diet, epidemiology, irritable bowel syndrome, micronutrients, nutrition

Received: 2 May 2017; revised manuscript accepted: 28 September 2017.

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Introduction

Irritable bowel syndrome (IBS) is a chronic functional gastrointestinal disorder characterized by abdominal pain or discomfort and altered bowel habits, with different subtypes such as constipation predominant (IBS-C), diarrhea-predominant (IBS-D) and alternating constipation/diarrhea (IBS-M).[1] It is estimated to affect around 10–15% of the population,[2] women being more frequently affected with a two- to three-fold increase.[3] While IBS is not a life-threatening disease, patients with severe symptoms may experience an altered quality of life,[4–6] and IBS represents an important economic burden for society due to important direct and indirect costs.[7]

The pathophysiology of IBS is complex and includes peripheral and central mechanisms.[8,9] Food and diet are also suggested to play a central role in IBS, as different studies have reported associations between dietary components and

several mechanisms involved in IBS, such as gut microbiota, intestinal motility and permeability, bile acid metabolism, visceral sensitivity and psychological factors.[9] Two-thirds of patients report that eating can elicit or worsen digestive symptoms but only a minority are able to incriminate a single food.[8,10–15] Patients are often influenced by dietary advice provided in the media (internet, press and TV), which promotes various popular diets and underline their potential health benefits, such as being lactose-free and gluten-free and, more recently, the low FODMAP diet. Following such influences, or even spontaneously, patients can modify their diets, sometimes reducing their symptoms but with the risk of micronutrient deficiencies.[16,17]

Few studies have investigated the association between IBS and eating behavior or nutrient intake in the general population, and all reported no association between IBS subtypes and nutrient intake. However, these studies included a limited number of patients and control subjects. The aim of our study was therefore to compare the diets in terms of food consumption and nutrient intake between subjects with IBS and controls in a large French population.

Methods

Population

The Nutrinet-Santé Study is a web-based prospective observational cohort, aiming at investigating the relationships between health and nutrition. The study includes subjects aged over 18 years, and started in France in May 2009; it is still ongoing. At baseline, participants completed self-administered questionnaires about socioeconomic, lifestyle, health status, diet, physical activity, and anthropometric data. During follow-up, additional questionnaires are regularly provided and participants are free to complete them or not. The complete methodology has been described elsewhere.[18,19] The study is performed in accordance with the Declaration of Helsinki and was approved by the Institute Review Board of the French Institute for Health and Medical Research (00000388FWA00005831) and the Commission Nationale Informatique et des Libertes (908450 and 909216). All participants provided electronic informed consent.

Data collection

A questionnaire assessing functional gastrointestinal disorders (FGIDs) was sent to the whole cohort between 21 June and 6 November 2013, including data on medical digestive history and symptoms using the Rome III criteria questionnaires. The Rome III criteria were used to define IBS (with minimal symptom durations of at least 6 months) and IBS subtypes (IBS-C, IBS-D, IBS-M and IBS-undefined).[20,21] Subjects reporting other functional diseases (dyspepsia, diarrhea, constipation) or any organic diseases (stomach, esophagus or colorectal cancers, familial adenomatous polyposis coli, Crohn's disease, coeliac disease, ulcerative colitis) or alarm symptoms (melena, hematemesis, rectal bleeding or significant unintentional weight loss in the past 3 months), were excluded from the present study. History of upper gastrointestinal endoscopy and colonoscopy (yes/no) were included in the questionnaire on FGIDs.

Dietary data

At baseline and prospectively every 6 months, participants were invited to complete a set of three web-based self-administered 24 h dietary records. These records were non-consecutive and randomly distributed between week and weekend days in a 2-week period, with 2 weekdays and a weekend day. Dietary data were weighted according to the day of the record (weekday or weekend day). All participants who completed at least three 24 h records until the completion of the questionnaire pertaining to FGIDs were eligible. Each food and beverage consumed was collected according to three main meals (breakfast, lunch and dinner) and three possibilities of snacks. Participants had to estimate the portion size for each item consumed using validated photographs.[22] Energy and nutrient intakes were estimated using the 'NutriNet-Santé' food composition table,[23] including more than 2500 different foods. This web-based dietary assessment was compared with a traditional dietitian's interview and showed a good agreement with this gold standard.[24,25]

Sociodemographic and lifestyle data

At baseline, information on age, gender, body mass index (BMI) (computed from self-reported weight and height and categorized as normal/

overweight or obese), smoking status (current smoker/former smoker/nonsmoker) and educational level (no diploma or primary studies/secondary studies or higher educational level) were collected using self-administered questionnaire on the internet.

Statistical analysis

A comparison of sociodemographic, lifestyle, anthropometric and medical information was performed according to gender using *t* test and chi-square tests. Association between IBS and diet was evaluated by comparison tests controlled for gender, age and total energy intake using ANCOVA tests. Interactions according to age, history, colonoscopy and upper gastrointestinal colonoscopy were tested. Comparison tests with *p*-values <0.001 were considered statistically significant in order to take into account the multiplicity of tests. Statistical analyses were conducted using the SAS statistical package release 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

In the Nutrinet-Santé Study, 57,037 individuals completed the FGIDs questionnaire. Among them, 49,458 had at least three 24 h records. The 13,010 participants suspected to have digestive diseases or symptoms previously cited were excluded. The characteristics of the 36,448 subjects included in this study are shown in Table 1. Included participants were mainly women (76.9%) and the mean age was 50.2 ± 14.2 years. Among these individuals, 1870 (5.1%) presented with IBS, with a higher prevalence in women compared to men (5.4 *versus* 4.4%, $p < 0.001$). Among IBS patients, 402 subjects had IBS-C (21.5%), 617 IBS-D (33.0%), 673 IBS-M (36.0%) and 178 IBS-undefined (9.5%). The mean BMI in IBS patients was 24.0 ± 4.5 kg/m², and in healthy controls was 23.8 ± 4.3 kg/m² ($p = 0.14$). Among IBS patients, 732 (39.1%) had a history of upper gastrointestinal endoscopy *versus* 6463 (18.7%) in healthy controls ($p < 0.0001$). Concerning a history of colonoscopy, 902 (48.2%) IBS patients had undergone one, while 7404 (21.4%) of healthy controls had done so ($p < 0.0001$).

Table 2 shows the comparison of mean food consumption between controls and IBS patients adjusted for age, gender and total energy intake. Compared to controls, individuals with IBS had significantly lower consumption of milk (74.6 *versus* 88.4 g/day; $p < 0.0001$), yogurt (108.4 *versus* 115.5 g/day; $p = 0.001$), fruits (192.3 *versus* 203.8 g/day); $p < 0.001$), and higher consumption of non-sugared drinks (1105.8 *versus* 1065.1 ml/day; $p < 0.001$).

Table 3 summarizes the mean daily intake in terms of macronutrients in healthy controls and IBS patients controlled for gender, age and total energy intake. The cases reported higher total energy intake (2028.9 *versus* 1995.7 kcal/day; $p < 0.001$), with a slightly higher percentage of energy from fat (38.5 *versus* 38.1% of total energy intake; $p = 0.001$) and lower percentage of energy from proteins (16.4 *versus* 16.8% of total energy intake; $p < 0.0001$). Percentage of energy from carbohydrates did not differ significantly. However, healthy controls tended to reach the recommended level in fiber ($\geqslant$25 g/day) less often than IBS patients (16.8 *versus* 18.4%; $p = 0.07$).

The mean daily intake of micronutrients is presented in Table 4, controlled for gender, age and total energy intake. Consumption of calcium, potassium, zinc and vitamins B2, B5 and B9 were significantly lower in IBS patients compared to healthy controls, with borderline significant associations for phosphorus and vitamins B1 and C. No significant differences were observed for other nutrients. Furthermore, most of the food groups and nutrient intakes were not significantly different according to subgroups of IBS (see supplementary files).

Discussion

This study performed in a large French sample from the general population suggests that dietary behavior differs between IBS patients and controls. Consumption of milk, yogurt, fruits and higher consumption of non-sugared drinks were significantly lower in those suffering IBS compared to controls, which impacted nutrient intakes (lower consumption of proteins, lipids, calcium, potassium, zinc, vitamins B2, B5 and B9).

In our study, IBS patients had higher total energy intake while there was no significant difference for BMI, which is consistent with earlier findings. Williams and colleagues previously reported that subjects with IBS had higher energy intakes than their estimated average

Table 1. Characteristics of the sample according to gender and comparison between healthy controls and IBS patients, $n = 36{,}448$.

	Men, $n = 8414$ (23.1%)		Women, $n = 28{,}034$ (76.9%)		p-value*	Controls, $n = 34{,}578$ (94.9%)		IBS, $n = 1870$ (5.1%)		p-value *
	N	%	*N*	%		*N*	%	*N*	%	
Age										
18–25	151	1.8	1309	4.6	<0.0001	1420	4.1	40	2.1	<0.0001
26–49	2596	30.8	12,331	44.0		14,563	42.1	364	19.5	
50–64	2994	35.6	10,509	37.5		12,479	36.1	1024	54.8	
⩾65	2673	31.8	3885	13.9		6116	17.7	442	23.6	
Educational level										
No diploma and primary studies	327	3.9	756	2.7	<0.0001	1022	3.0	61	3.3	0.63
Secondary studies	2946	35.2	9167	32.9		11,484	33.4	629	33.9	
High educational level	5092	60.9	17,911	64.4		21,840	63.6	1163	62.8	
Smoking status										
Nonsmoker	3539	42.1	15,328	54.7	<0.0001	17,962	51.9	905	48.4	<0.0001
Ex-smoker	3921	46.6	9073	32.4		12,226	35.4	768	41.1	
Smoker	954	11.3	3633	12.9		4390	12.7	197	10.5	
BMI										
<25	4787	56.9	20,269	73.4	<0.0001	23,770	69.6	1286	68.9	0.79
25–30	2900	34.5	5063	18.3		7546	22.1	417	22.4	
⩾30	726	8.6	2292	8.3		2855	8.4	163	8.7	
Upper gastrointestinal endoscopy (yes)	1838	21.8	5357	19.1	<0.0001	6463	18.7	732	39.1	<0.0001
Colonoscopy (yes)	2349	27.9	5957	21.3	<0.0001	7404	21.4	902	48.2	<0.0001
IBS by subtype										
No	8043	95.6	26,535	94.6	<0.0001					
Constipation	44	0.5	358	1.3				402	21.5	
Diarrhea	145	1.7	472	1.7				617	33.0	
Mixed	162	1.9	511	1.8				673	36.0	
Undefined	20	0.3	158	0.6				178	9.5	

*Chi-square test and *t* tests were performed. Missing data for 249 individuals for the educational level and 411 subjects for the BMI.
BMI, body mass index; IBS, irritable bowel syndrome.

requirements[26]; Zheng and colleagues showed that IBS patients had higher energy intakes than a non-IBS group[27]; and Simren and colleagues showed that BMI did not differ between controls and IBS patients.[15] Higher energy intakes in IBS patients may be related to higher requirements in subjects with IBS to compensate for malabsorption or bowel motility dysfunction, or may be the results of higher energy expenditure.[26] In spite of higher energy intakes, we observed lower

Table 2. Comparison of daily intake of food groups between healthy controls and IBS patients (n = 36,448).

Food groups (g)	Controls, n = 34,578 (94.9%)		IBS, n = 1870 (5.1%)		p-value*
	Mean	SE	Mean	SE	
Meat, poultry	89.4	0.3	87.9	1.0	0.15
Pork hams, poultry cuts, processed meat	45.2	0.2	44.5	0.6	0.29
Offal	12.7	0.1	11.9	0.5	0.11
Fish, shellfish, processed fish and shellfish	67.2	0.3	67.1	1.0	0.89
Eggs	20.5	0.1	19.5	0.4	0.02
Fat products	50.6	0.1	51.4	0.4	0.04
Milk	88.4	0.7	74.6	2.7	<0.0001
Cheese	38.8	0.1	38.9	0.5	0.84
Yogurt, cottage cheese, petits Suisses	115.5	0.6	108.4	2.1	<0.001
Milk based-desserts	52.3	0.3	53.0	1.1	0.53
Fruits	203.8	0.8	192.3	2.9	<0.0001
Dry fruits, oleaginous fruit	13.8	0.1	14.7	0.4	0.03
Vegetables	216.2	0.6	216.8	2.3	0.77
100% vegetables and fruits juice	72.8	0.5	73.0	1.8	0.88
Pulses	24.9	0.2	23.4	0.7	0.03
Potatoes	56.5	0.2	56.5	0.8	0.95
Cereals products	209.6	0.5	209.2	1.9	0.84
Wholegrain products	53.7	0.4	51.5	1.3	0.09
Breakfast cereals	15.8	0.2	16.3	0.6	0.41
Salty and sweet snack products	156.8	0.5	160.2	1.7	0.04
Non-sugared beverages	1065.1	3.2	1105.8	11.6	<0.001
Soft sugary drinks	57.8	0.6	61.4	2.0	0.07
Alcoholic beverages	130.0	0.8	130.1	2.9	0.97

*ANCOVA tests controlled for gender, age and total energy intake.
ANCOVA, analysis of covariance; IBS, irritable bowel syndrome; SE, standard error.

mean micronutrient intakes in IBS patients. This may reflect an unbalanced diet that could have long-term health consequences.

The inverse association between milk and yogurt consumption and IBS may be explained by a frequent lactose intolerance in these patients,[28,29] and the beliefs by patients that symptoms may be caused by lactose.[30,31] Lactose-containing products are suspected to aggravate gastrointestinal symptoms.[32–34] The inverse association observed with dairy-product consumption may also explain the lower percentage of energy from protein observed in our study – more precisely in animal protein intake – and lower calcium intake. Mixed findings on the relationship between milk and dairy consumption and IBS have been observed. Some studies reported that subjects with IBS avoided milk products and had lower intakes of calcium,[17,35] such as the study of Ligaarden and colleagues.[36] Similarly, Ostgaard and colleagues have showed that healthy controls consumed 267.9 g/day) of

Table 3. Comparison of daily intake of macronutrients between healthy controls and IBS patients (n = 36,448).

	Controls, n = 34,578 (94.9%)		IBS, n = 1870 (5.1%)		p-value*
	Mean	SE	Mean	SE	
Energy (kcal)	1995.7	2.4	2028.9	8.8	0.0002
Percentage energy from fat	38.1	0.0	38.5	0.1	0.001
MUFA (g)	29.3	0.0	29.8	0.1	0.001
PUFA (g)	11.1	0.0	11.1	0.1	0.67
SFA (g)	32.0	0.0	32.3	0.2	0.12
Cholesterol (mg)	311.0	0.6	307.0	2.1	0.05
Percentage energy from proteins	16.8	0.0	16.4	0.1	<0.0001
Animal protein (g)	54.0	0.1	52.6	0.3	<0.0001
Vegetable protein (g)	24.9	0.0	24.8	0.1	0.31
Percentage energy from carbohydrates	41.4	0.0	41.4	0.1	0.92
Complex carbohydrates (g)	104.3	0.2	104.3	0.5	0.99
Simple carbohydrates (g)	88.4	0.2	88.4	0.5	0.95
Fibers (g)	19.4	0.0	19.3	0.1	0.13

*ANCOVA tests controlled for gender, age and total energy intake, except for energy, lipids, proteins and carbohydrates.
ANCOVA, analysis of covariance; IBS, irritable bowel syndrome; kcal, kilocalories; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

low-fat milk products and 1184.3 mg of calcium compared with the 72.8 g of milk products and 825.8 mg/day of calcium.[17] On the other hand, some studies have shown that IBS patients consume milk more frequently.[26,37] Lactose intolerance has similar symptom profiles to IBS,[38] but other components could be involved.[39] More studies are therefore needed to investigate these associations and the associated symptoms.

The percentage of energy from fat was higher in IBS patients compared to healthy controls. This result may be partly explained by a trend in higher consumption of fats, mainly of vegetable oils. This finding is consistent with the study of Saito and colleagues that found that IBS cases consumed 33.1% of energy from fat compared with 30.7% in controls, and particularly more MUFA, as we observed.[37] Likewise, Bohn and colleagues tended to show slightly higher intake of lipids in IBS in a sample of 561 individuals.[16] A decrease in gastric emptying, increase in gas retention in the small bowel and greater rectal sensitivity have been associated with consumption of foods rich in lipids.[40,41] This effect may influence patients to consume fewer products that provide fat. Interestingly, while PUFA metabolites are increased in colon biopsies of IBS patients and are suspected to be involved in sensitization of neurons, we found similar levels of PUFA intake in IBS and controls.[42]

Our results show that subjects with IBS consumed less fruit, which can impact the daily intake of water-soluble vitamins and minerals. Indeed, IBS patients had lower daily intakes of B2, B5 and B9 vitamins, potassium and zinc, which is consistent with other studies.[16,26,36] Some fruits – including apples, pears, mangos, cherries and lychees – are suspected of triggering some symptoms in IBS, such as gas production by fermentation,[43] and to have laxative effects with a FODMAP mechanism.[44–46] Therefore, subjects with IBS, aware of these effects, may have reduced their consumption of fruit to avoid symptoms. However, fiber intake did not appear to be impacted, as this was

Table 4. Comparison of daily intake of micronutrients between healthy controls and IBS patients ($n = 36,448$).

	Controls, $n = 34,578$ (94.9%)		IBS, $n = 1870$ (5.1%)		*p*-value*
	Mean	SE	Mean	SE	
Calcium (mg)	905.6	1.4	888.5	5.0	0.001
Iron (mg)	13.3	0.0	13.2	0.1	0.05
Potassium (mg)	2967.6	3.6	2924.1	12.9	0.001
Magnesium (mg)	336.5	0.6	335.3	2.1	0.58
Sodium (mg)	2831.9	3.8	2831.5	13.5	0.97
Zinc (mg)	10.7	0.0	10.5	0.1	<0.0001
Phosphorus (mg)	1258.2	1.5	1243.4	5.3	0.01
Beta carotene (µg)	3384.3	13.0	3391.2	46.7	0.88
Vitamin A (mg)	1064.7	3.7	1055.7	13.1	0.49
Vitamin B1 (mg)	1.2	0.0	1.2	0.0	0.02
Vitamin B2 (mg)	1.7	0.0	1.7	0.0	<0.001
Vitamin B5 (mg)	5.2	0.0	5.1	0.0	<0.0001
Vitamin B6 (mg)	1.7	0.0	1.7	0.0	0.24
Vitamin B9 (µg)	319.4	0.5	313.5	1.9	0.002
Vitamin B12 (µg)	5.4	0.0	5.3	0.1	0.19
Vitamin B3 (mg)	18.7	0.0	18.5	0.1	0.09
Vitamin C (mg)	111.5	0.4	108.0	1.3	0.01
Vitamin D (µg)	2.7	0.0	2.7	0.0	0.37
Vitamin E (mg)	11.2	0.0	11.3	0.1	0.39

*ANCOVA tests controlled for gender, age and total energy intake.
ANCOVA, analysis of covariance; IBS, irritable bowel syndrome.

not significantly different between subjects with IBS and controls, as found by Zheng and colleagues and Saito and colleagues.[27,37] Our results are consistent with these findings, and no differences in fiber intake were observed even in the subtype of IBS with predominant constipation. However, contradictory data have been published by Bohn and colleagues, who found an increase in fiber intake in IBS patients.[16]

The consumption of non-sugared beverages – including water, tea, coffee and light soda – was higher in IBS patients than in controls. Our results are in agreement with the literature; Ligaarden and colleagues reported previously that IBS patients had higher intakes of water.[36] Individuals with IBS may have followed recommendations to drink more water in IBS in order to compensate for diarrhea and to avoid constipation.[47]

Taken together our findings tend to support the idea that IBS patients adapt their diets according to symptoms or recommendations (medical or not). Indeed, most IBS patients considered that diet could activate or trigger their symptoms,[15] and as such they may restrict use of some food groups. Some studies have already reported that IBS patients have digestive symptoms triggered by certain food groups, such as dairy products, meat, cabbage, hot spices and coffee[15,48]; this can lead to selective food choices. Indeed, in a study performed with 222 members of the French organization of patients suffering from IBS, 46% were following or had followed a specific diet.

A systematic review reported on the limited evidence available on the effect of dietary intervention in IBS patients.[49] While clinicians do not recommend an exclusion diet,[50] patients could still be influenced by the popularity of new exclusion diets such as the low FODMAP diet (fermentable oligo-di-monosaccharides and polyols) or gluten-free diets. Subjects with IBS could be receptive to advice from the media regarding reducing their symptoms. Many mechanisms are thought to be involved in the relationship between diet and symptoms, including visceral hypersensitivity, gas production, microbiota composition and digestive transit.[51] Individual dietary guidance based on their subjective and individual food intolerances appears to be of utmost importance.[17]

Our study has some strengths. To our knowledge, it is the first study to investigate the comparison of dietary intakes between IBS patients and healthy controls with such a large population base, and the first one in France. The identification of IBS was based on the Rome III criteria.[1] Despite the fact that the participants were identified using only self-reported Rome III criteria without a direct interview for diagnosis based on physician expertise, the high proportion of colonoscopy and endoscopy performed in the IBS group suggest many of the identified subjects had been diagnosed with IBS by a physician. Moreover, the comparisons between IBS and controls were controlled for age, gender and total energy intake, therefore taking into account the differences in dietary behavior according to these variables. Additionally, we have tested interactions in order to investigate the direction of the relationship in a causality framework, though not all tests were significant. There were no differences in the associations according to the age of the participant or the history of colonoscopy. Moreover, we have excluded subjects reporting other functional diseases or any organic diseases in order to reduce misclassification bias.

However, some limitations in this study should also be noted. This is a cross-sectional study and we are not able to infer a causal relationship either regarding diets leading to IBS or diets modified because of IBS diagnoses. Furthermore, the observed differences in eating habits could have occurred after the diagnosis. Another limitation was that subjects were recruited from the general population with access to the internet and willing to complete several online questionnaires for a study where the main purpose is nutrition. They are more likely to be health-conscious and have more controlled diets. Therefore, we have probably underestimated the prevalence. That could explain the few differences in diet intake observed, especially by IBS subtypes. Finally, our study population was drawn from a voluntary cohort study. Therefore, our sample is not representative of the general population. As such, these IBS patients may differ from IBS patients overall. However, prevalence was in agreement with other population-based studies. One limitation of the diagnosis was the non-possibility to validate the presence of IBS as an actual medical diagnosis, and no specific medication would have allowed us to directly identify subjects with diagnosed IBS. Another limitation was the inaccessibility of the medical records, in particular for disease duration, severity and psychological factors, but the selection criteria of the sample minimize this potential bias. Finally, self-reported dietary assessments are frequently subject to many biases, especially memory bias in 24 h) records and under-reporting. Nevertheless, we have used three or more 24 h records that could help to minimize these biases, and the mean intakes reported were comparable to similar studies. Moreover, internet surveys could introduce many biases in the dietary assessment; however, in our cohort, dietary records were validated against interviews by dieticians and biomarkers of nutritional status.[25]

In conclusion: in this large study sample from the general population, IBS patients appear to have different eating behaviors than healthy controls. Some findings suggest that their diet is modified, and could be guided by their own symptoms and beliefs. Dietary guidance is needed to recommend a suitable diet adapted for each individual. However, further studies are required to investigate the causality of the associations that we and others have observed.

Contributorship statement

MJT analyzed the data and led the writing; CJ supervised the research; CJ and MB constructed the questionnaire; CJ, JMS and MB assisted with interpretation of the data; SH designed the study and monitored the data collection; CJ, JMS, MB and SH critically revised the manuscript. All authors approved the final version of the manuscript.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The Nutrinet-Santé Study is supported by the French Ministry of Health, the Institut de Veille Sanitaire, the Institut National de la Santé et de la Recherche Médicale, the Institut National de la Recherche Agronomique, the Conservatoire National des Arts et Métiers, the Institut National de Prévention et d'Education pour la Santé and the Fondation pour la Recherche Médicale and Paris 13 University. This study received a grant from the Société Nationale Française de Gastro Entérologie. The funders and sponsors played no role in the study design, the collection, management, analysis, interpretation of the data, decision to publish or preparation of the manuscript. Researchers are independent from funders and sponsors. All researchers had access to all the data.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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