Habitual diet and diet quality in Irritable Bowel Syndrome


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INTRODUCTION

Diet is considered to be a key factor in symptom generation in Irritable Bowel Syndrome (IBS) and may contribute to onset and progression of the disorder. Management of IBS is based on several treatment strategies that embrace dietary, lifestyle, medical, and behavioral interventions, with varying efficacy. As a consequence of the lack of efficacious treatment options, many patients turn to self-treatment, often related to dietary restrictions, which may lead to impaired diet quality. A large

Abstract

Background: Diet is considered to be a key factor in symptom generation in Irritable Bowel Syndrome (IBS) and patients tend to exclude food products from their diet in pursuit of symptom relief, which may impair diet quality.

Methods: We evaluated habitual dietary intake in IBS patients with regard to nutrients and food products using an extensive food frequency questionnaire. One hundred ninety-four IBS patients were compared to 186 healthy controls using multiple logistic regression analysis. An overall diet quality score was calculated for each participant based on the criteria of the Dutch Healthy Diet (DHD) index.

Key Results: A lower DHD-score was found for IBS (mean [SD]: 52.9 [9.6]) vs controls (55.1 [9.2], P = .02). The diet of patients was lower in fibers (21 g vs 25 g per day, P = .002) and fructose (14 g vs 16 g, P = .033), while higher in total fat (37% vs 36% of total energy intake, P = .010) and added sugars (46 g vs 44 g, P = .029). Differences in daily intake of food products included lower consumption of apples (40 g vs 69 g, P < .001), pasta (28 vs 37 g, P = .029) and alcoholic beverages (130 g vs 193 g, P = .024) and higher consumption of processed meat (38 g vs 29 g, P < .001). Some of these findings correlated with gastrointestinal symptoms, showing differences between IBS subtypes.

Conclusions and Inferences: Differences in habitual diet were described, showing lower diet quality in IBS patients compared to controls, with increased consumption of fat and lower intake of fibers and fructose. Our data support the importance of personalized and professional nutritional guidance of IBS patients.

KEYWORDS
diet quality, habitual diet, irritable bowel syndrome

1 | ORIGINAL ARTICLE

Habitual diet and diet quality in Irritable Bowel Syndrome: A case-control study

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European study indicated that over 60% of IBS patients limited or excluded food products from their diet. Several studies showed potential beneficial effects of restricting certain nutrients, such as fermentable oligo-, di-, monosaccharides and polyols (FODMAPs). The British dietetic association advises the use of these restrictions as second line treatment to be provided by a professional dietitian for 3-4 wk to evaluate potential symptom relief in IBS patients. It has to be noted that recent evidence indicates that the low FODMAP diet was effective, but was not superior to traditional dietary advice nor hypnotherapy in IBS patients. Furthermore, no effect was found in proportion of composite end point responders when compared to the modified NICE guidelines in patients with diarrhea predominant subtype. However, in that study, it did lead to significant improvement in some secondary endpoints, such as a higher proportion in abdominal pain responders. Moreover, dietary restrictions can also have a negative impact on disease-specific quality of life in patients with IBS and it is still not clear what is the long-term outcome, how strict such a diet should be and which patients may benefit most.

Previous studies have investigated habitual dietary patterns in IBS patients, yielding some contradictory results. Significant differences in protein, fiber and alcohol intake, and in the intake of micronutrients such as calcium and beta carotene, between IBS patients and healthy controls were described. On the other hand, not all studies found significant differences between these groups in the intake of macronutrients, micronutrients or food groups. Comparisons between studies is hampered by differences with regard to geographic and cultural related dietary variations and by methods used to assess nutritional intake. Moreover, while dietary restrictions bear the risk of impaired diet quality, data on the overall quality of the habitual diet of IBS patients are limited.

Therefore, we undertook an observational study using a standardized and comprehensive food frequency questionnaire (FFQ) in a large Dutch cohort of IBS patients and controls to assess habitual dietary intake in IBS patients, with special emphasis on the overall diet quality.

2 MATERIALS AND METHODS

This case-control study is part of the Maastricht IBS cohort (MIBS), a large prospective cohort study on the phenotypic and genetic characterization of IBS patients. The study was approved by the MUMC+ Medical Ethics Committee, in compliance with the revised Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, 2013), and is registered in the US National Library of Medicine (http://www.clinicaltrials.gov, NCT00775060).

Firstly, the dietary intake between IBS patients and controls was investigated with respect to nutrients, and the consumption of individual food products. Secondly the overall diet quality was studied using a dietary index that measures adherence to the Dutch nutritional guidelines. And thirdly associations between diet and patient characteristics were evaluated.

Key Points

- Diet is considered to be a key factor in symptom generation in Irritable Bowel Syndrome and patients tend to exclude food products from their diet in pursuit of symptom relief.
- Habitual diet of IBS patients differs compared to controls and the quality of diet of IBS patients is lower.
- Our data support a prominent role for personalized and professional nutritional guidance in daily care of IBS patients, with focus on diet quality.

2.1 Participants

The MIBS cohort includes IBS patients (aged 18-75 y) from primary and hospital (secondary/tertiary) care, enrolled via regional GP practices and the outpatient clinic of Maastricht University Medical Hospital+ (MUMC+). IBS diagnosis and subtypes were defined by the Rome III criteria. Prior to making the diagnosis, medical history was taken by a physician, and gastrointestinal (GI) endoscopy with biopsies, abdominal imaging by ultrasonography or CT scan and/or blood, breath, and fecal analyses were performed to exclude organic disease, if indicated. Patients with a history of abdominal surgery, except appendectomy, laparoscopic cholecystectomy and hysterectomy, were excluded. Healthy controls from the same geographical region, without GI symptoms were recruited via public advertisements. Before participation, an extensive interview including a medical history was taken by a physician to exclude the presence of GI disorders and current or previous GI complaints. As the objective of this study was to compare the habitual diet between IBS patients and healthy subjects from the general population, the use of specific diets in everyday life of the study participants, such as a vegetarian diet, was noted but not considered an exclusion criterion. All participants gave written informed consent prior to inclusion. Data on medical history and demographic characteristics was collected as described in detail previously, and all subjects completed several questionnaires: the Gastrointestinal Symptom Rating Scale (GSRS) and a 14-d GI symptom diary for the assessment of GI symptoms, the Hospital Anxiety and Depression Scale (HADS) for scores of anxiety and depression, and the 36-item Short Form Health Survey (SF-36) for the assessment quality of life.

2.2 Food intake

Habitual dietary intake was assessed in IBS patients and healthy controls between May 2012 and April 2015 by a self-administered food frequency questionnaire using intake over the previous month as reference period. This FFQ was developed and validated by the division of Human Nutrition of Wageningen University using standardized procedures. The data on frequency and types of foods consumed were linked to the Dutch food composition table (NEVO 2011, RIVM,
In this study, cross-sectional data of 194 IBS patients (106 primary care and 88 secondary-tertiary care patients) and 186 healthy controls were available for analyses (Table 1). Age was comparable in patients and controls. The IBS group included a significantly higher percentage of women as well as smokers and had a higher BMI. IBS patients also reported higher scores of GI symptoms in the 14-day diary and the GRSRs. Moreover, IBS patients had lower quality of life scores and a higher prevalence of a positive indication for symptoms of anxiety and depression (i.e. HADS score ≥8). Adherence to a special diet, as indicated by the participants, was 18.0% in IBS patients vs 10.8% in the control group (P=.057) (Table 1). Most frequently reported diets in patients and controls included energy-restricted (3.6% vs 2.2%, respectively) and vegetarian diet (2.1% vs 6.5%, respectively).

In addition, adherence to a lactose-free or gluten-free diet was reported by 2.6% and 2.1% of IBS patients, respectively, and by none of the control subjects. A low FODMAP diet was not reported by any of the study participants.
3.1 | Differences in nutrient and food intake in IBS patients vs controls

Nutrient intake analysis showed that IBS patients had a significantly lower intake of energy compared to controls. Furthermore, the intake of fiber, fructose and alcohol was lower relative to controls (Figure 1 and Table S3). In contrast, the dietary proportion of fat and intake of added sugars was significantly higher in IBS patients than in controls. Analysis of food groups showed a significantly lower mean intake of alcoholic beverages, cereals, pasta and rice, and a significantly higher intake of bread with low fiber content and processed meat in IBS patients (Table 2). In addition, the user analysis showed that a larger proportion of IBS patients did not consume bread with high fiber content, cereals, low fat dairy, nuts, and raw vegetables (Table 2).

At the level of food products, IBS patients were found to have a significantly lower mean intake of some foods, for example, apples and muesli, while intake of sandwich meat was higher (Figure 2A and Table S4). Additionally, significantly fewer IBS patients used food products such as nuts, cooked onion or leek, and coffee (Figure 2B and Table S5).

Furthermore, no statistically significant differences were observed between primary and hospital care IBS patients with regard to nutrient and food intake.

3.2 | Comparison of food intake to Dutch nutritional guidelines

Data on 8 out of 10 components of the DHD-index were available for analysis in this study, resulting in a maximum score of 80. The component scores of the DHD-index in controls were comparable to the scores in the reference population from van Lee et al. consisting of 121 men and women. The DHD-score ranged between 26.5 and 78.4 points. On group level, a lower score in IBS patients vs controls was found, mean (SD): 52.9 (9.6) vs 55.1 (9.2), \( P = .02 \), respectively. This difference was mostly based on differences in intake of fruits, fibers and saturated fat. Overall both, the IBS and control groups, scored low on the components for fish and vegetable consumption and high on saturated fatty acid and salt intake when compared to the Dutch nutritional guidelines.

Comparison of the DHD scores within the IBS group between the lowest tertile \( (n=64) \) and the highest tertile of cases \( (n=65) \) yielded a difference of 18.9 points \( (43.7 \ [39.5-46.5]) \) vs \( 62.6 \ [60.2-66.4] \) (Figure 3). The lowest tertile included significantly more men \( (34\% \ vs \ 15\%, P=.015) \) and IBS patients with the diarrhea predominant subtype (IBS-D) \( (45.3\% \ vs \ 26.2\%, P=.028) \) when compared to the highest tertile. In line with this subtype distribution, the end-of-day diary mean scores for diarrhea and GSRS scores for loose stools were higher in the lowest
compared to the highest tertile; 1.4 [1.0-1.8] vs 1.1 [1.0-1.4] (P=.034), respectively, and 4.0 [2.0-5.0] vs 3.0 [1.0-4.5] (P=.046), respectively. No differences were found with regard to other patient characteristics, including demographic factors, other GI symptom scores, anxiety or depression scores or quality of life between these groups.

### 3.3 Correlations of differential food intake with gastrointestinal symptoms

Correlations were investigated between GI symptom scores with nutrients and food items that were significantly different in intake in IBS patients vs controls. These analyses were done for IBS subtypes as symptoms may vary between subtypes. In IBS-D patients, lower total fiber intake (in E%) correlated significantly with higher symptom scores for diarrhea (r=-.36, P=.004), but no statistically significant correlations to fiber intake were found for other symptoms and for other subtypes. For constipation predominant IBS (IBS-C) patients, we observed positive correlations of apple consumption with abdominal discomfort (r=.43, P=.008) and constipation (r=.46, P=.004), and cereal consumption with flatulence (r=.44, P=.006). Consumption of cooked onion or leek negatively correlated with bloating in IBS-C patients (r=-.43, P=.008). In IBS patients with mixed stool pattern (IBS-M),

| Table 2 Percentage users, mean intake (grams per day) and standard deviation of food groups in IBS patients and controls |
|---|---|---|---|---|---|---|---|---|
| Food group | IBS patients (n=194) | Controls (n=186) | User P-value | P-value | OR |
| | % | Mean | SD | % | Mean | SD | | |
| Alcoholic beverages (g) | 79.4 | 130.2 | 220.9 | 84.9 | 192.8 | 247.8 | .229 | .024 | 0.73 |
| Non-alcoholic beverages (g) | 76.3 | 155.9 | 206.8 | 81.7 | 131.1 | 217.3 | .260 | .246 | 1.15 |
| Bread high fiber (g) | 79.4 | 66.6 | 62.8 | 87.6 | 87.0 | 68.9 | .020 | .147 | 0.83 |
| Bread low fiber (g) | 94.8 | 61.0 | 61.5 | 90.9 | 54.2 | 51.4 | .215 | .018 | 1.30 |
| Cereals (g) | 41.2 | 7.9 | 16.3 | 52.2 | 11.8 | 21.0 | .018 | .042 | 0.76 |
| Cheese (g) | 95.9 | 27.2 | 27.2 | 97.8 | 31.0 | 28.9 | .258 | .374 | 0.89 |
| Coffee, tea, water (g) | 99.5 | 1196.6 | 614.4 | 100.0 | 1104.6 | 552.8 | NA | .241 | 1.13 |
| High fat dairy (g) | 98.5 | 168.2 | 165.8 | 98.9 | 169.8 | 137.3 | .640 | .551 | 1.06 |
| Low fat dairy (g) | 41.8 | 31.7 | 66.8 | 54.3 | 59.8 | 127.2 | .010 | .066 | 0.74 |
| Eggs (g) | 93.3 | 14.0 | 14.5 | 96.2 | 13.3 | 13.3 | .267 | .168 | 1.16 |
| Fish (g) | 85.6 | 15.7 | 16.1 | 85.5 | 15.8 | 14.0 | .964 | .747 | 1.03 |
| Fatty fish (g) | 64.9 | 5.3 | 7.1 | 72.6 | 6.4 | 7.4 | .099 | .544 | 0.93 |
| Fruit (g) | 97.9 | 199.9 | 145.3 | 100.0 | 237.4 | 173.1 | NA | .104 | 0.81 |
| Margarines, oils, sauces (g) | 100.0 | 54.3 | 37.6 | 100.0 | 55.2 | 31.9 | NA | .155 | 1.18 |
| Meat (g) | 95.9 | 48.1 | 29.3 | 93.0 | 48.1 | 39.0 | .171 | .168 | 1.19 |
| Processed meat (g) | 92.8 | 38.3 | 32.9 | 91.4 | 29.4 | 26.9 | .398 | <.001 | 1.59 |
| Nuts (g) | 77.3 | 10.3 | 13.6 | 89.8 | 16.3 | 24.5 | .002 | .057 | 0.71 |
| Pasta, Rice (g) | 99.0 | 53.9 | 48.5 | 98.4 | 71.6 | 62.4 | .736 | .019 | 0.72 |
| Pastry (g) | 96.9 | 33.7 | 30.0 | 98.4 | 39.5 | 30.5 | .253 | .742 | 0.96 |
| Potatoes (g) | 98.5 | 69.8 | 54.7 | 98.4 | 72.0 | 55.4 | .877 | .299 | 1.14 |
| Poultry (g) | 70.1 | 11.1 | 14.4 | 63.4 | 9.7 | 14.8 | .184 | .242 | 1.14 |
| Ready meal (g) | 79.9 | 33.2 | 43.7 | 85.5 | 40.4 | 50.6 | .109 | .717 | 0.95 |
| Snacks (g) | 87.6 | 22.6 | 31.0 | 88.2 | 19.9 | 26.6 | .726 | .095 | 1.21 |
| Soup (g) | 86.6 | 57.7 | 74.4 | 86.6 | 62.3 | 81.4 | .967 | .938 | 0.99 |
| Soy products (g) | 25.8 | 16.4 | 59.8 | 28.0 | 14.1 | 44.1 | .428 | .720 | 1.03 |
| Sugar, sweets (g) | 97.9 | 28.2 | 26.4 | 98.9 | 28.1 | 26.4 | .505 | .106 | 1.23 |
| Cooked vegetables (g) | 99.5 | 105.4 | 73.4 | 98.9 | 120.5 | 80.3 | .661 | .112 | 0.83 |
| Raw vegetables (g) | 86.1 | 29.2 | 30.6 | 92.5 | 32.0 | 41.4 | .033 | .495 | 0.92 |

*P*-value for difference in users between IBS patients and controls, adjusted for gender and age (logistic regression analysis);

*P*-value for difference in mean intake between IBS patients and controls, adjusted for gender, age, energy intake and smoking (logistic regression analysis); post hoc adjustment for BMI did not relevantly alter the results (data not shown).

OR per unit control SD; NA, not applicable.

*P*-values <.05 indicated in bold.
consumption of gingerbread (a national specialty eaten as a breakfast food or snack) negatively correlated with lower GI symptom scores for discomfort ($r=-.39$, $P<.001$) and pain ($r=-.36$, $P=.001$), whereas the consumption of apples positively correlated with a higher score for discomfort ($r=.33$, $P=.004$).

### 4 | DISCUSSION

In the current observational study, we describe the habitual dietary intake of IBS patients from primary and hospital care, and show that intake differs compared to controls with regard to the consumption of specific nutrients and specific food products. The overall diet of IBS patients scored lower on adherence to the Dutch nutritional guidelines compared to controls, which was more prominent for patients with IBS-D. Some of these findings correlated with gastrointestinal symptoms, showing differences between IBS subtypes.

The standardized FFQ we used in the present study has previously been applied to investigate self-reported dietary habits and energy intake in different populations. The translation of respondents’ answers into nutrients and food products provides detailed insight into the nutritional aspects regarding diet adequacy and into the food products that presumably are avoided by IBS patients. IBS patients tend to adjust their diet, usually without professional guidance. Unsupervised adaptations of the diet may result in impaired diet quality and inadequate nutrient intake. This has been subject of investigation in this study by evaluating the DHD-index. The DHD-index can be used to estimate the adherence to the Dutch guidelines for a healthy diet and is a good measure of nutrient density of diets. In this study, significantly lower scores for overall diet quality in IBS patients compared to controls was found. The mean difference in DHD-score between the IBS and control group was 2.2 point on an 80-point scale. A recent large 20-y follow-up study by van Lee et al. demonstrated that a lower level of adherence to the Dutch dietary guidelines in the general population, as assessed with the DHD-index, was associated with a higher risk of all-cause mortality, which was also found for small differences in DHD-index score. Furthermore, Hooft van Huysduynen et al. have demonstrated that an increase of 6.7 on the DHD-index was related to a significant decrease in waist circumference and in plasma phospholipid EPA and DHA, 20 wk after tailored dietary advice. Therefore, although the differences in DHD-index between IBS patients and HC was small, it may be clinically relevant. The median DHD-index score of the lowest tertile of IBS patients was 19 points lower compared to the highest tertile. For clinicians, it is important to identify these patients at risk and to focus on diet quality. While this group of IBS patients consisted of more men and IBS-D patients, no specific characteristic parameters were identified.

Between the highest and lowest tertiles of diet quality scores, no differences were found for anxiety and depressive symptoms or for quality of life in IBS patients. In the general population associations between depression and lower diet quality were reported previously. However, our findings are in line with those in a Swedish cohort of.
IBS patients, where psychological symptoms were not associated to nutrient intake. Also between GI symptom scores and diet quality we did not observe significant associations, apart from diarrhea and loose stool. Subtype-specific correlations between GI symptoms and overall fiber intake and some (fermentable) carbohydrate-rich foods, that is, apples, gingerbread, onion, leek, and cereals were found. In contrast to the studies on the low-FODMAP-approach in IBS, a higher total fiber intake correlated with lower symptom scores for diarrhea in the diarrhea-predominant IBS patients. No correlations were found for other symptoms, such as abdominal pain or bloating. In IBS-C and IBS-M higher intake of apples, which are rich in fructose, correlated to higher scores for abdominal discomfort. Furthermore, higher cereal intake correlated with increased flatulence scores in IBS-C. A cause and effect relationship cannot be dissected from the present observational study. Nevertheless, our findings may indicate that lower intake of fibers and of fermentable carbohydrate-rich food are not necessarily associated to lower GI symptom scores for all IBS patients. Our findings on differences in diet quality, which were most pronounced in IBS-D patients and subtype dependent correlations to symptoms, may stress the importance of personalized dietary guidance to improve diet quality and of professional support for IBS patients in dietary adaptations.

Our results on the mean daily intake of nutrients and food groups are comparable to those of other studies. The higher intake of fat, saturated fat, monounsaturated fat and processed meat in our IBS patients, has been observed previously. Likewise, our findings on IBS patients’ lower intake of alcohol, coffee, cereals, rice, and pasta (i.e. wheat based products) confirm previous reports. To the best of our knowledge, our study is the first to observe a difference in the habitual dietary intake of fructose and added sugars in IBS patients compared to controls, which may be initiated by the growing interest in FODMAPs restricted diets for IBS patients. Only ten IBS patients reported adherence to a lactose-free, fructose-free, or gluten-free diet, and none of the study participants indicated to adhere to a low FODMAP diet. However, we cannot exclude that IBS patients may have in part adjusted their diet in line with a low FODMAP approach, although the awareness with regard to this diet was lower during the inclusion period of this study, compared to present-day. Details on the intake of different carbohydrates were also assessed via a sugar-content-specific food composition table. The combined intake of mono-, di- and polysaccharides in our study population was comparable with the intake in the reference population from the Dutch food consumption survey. The intake of added sugars and individual mono- and disaccharides, however, was lower.

**FIGURE 3** Group differences in IBS patients in tertiles of DHD score. Boxes show the median and interquartile range. *P<.05 Fisher’s exact test, compared to tertile 3

<table>
<thead>
<tr>
<th>DHD median [range]</th>
<th>43.7 [39.5-46.5]</th>
<th>53.2 [51.4-54.8]</th>
<th>62.6 [60.2-66.4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>64</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>% women</td>
<td>66*</td>
<td>74</td>
<td>85</td>
</tr>
<tr>
<td>Age mean (SD)</td>
<td>44.9 (18.7)</td>
<td>45.0 (16.4)</td>
<td>45.7 (17.6)</td>
</tr>
<tr>
<td>BMI mean (SD)</td>
<td>24.9 (4.6)</td>
<td>25.0 (4.0)</td>
<td>24.8 (4.9)</td>
</tr>
<tr>
<td>% IBS C/D/M/U</td>
<td>17/45*/33/5</td>
<td>23/26/48/3</td>
<td>22/26/46/6</td>
</tr>
<tr>
<td>Overall symptom burden</td>
<td>2.5 (0.7)</td>
<td>2.4 (0.7)</td>
<td>2.5 (0.6)</td>
</tr>
<tr>
<td>Total GRS</td>
<td>16.6 (4.2)</td>
<td>16.5 (4.4)</td>
<td>15.9 (4.8)</td>
</tr>
<tr>
<td>% HADS depression ≥8</td>
<td>25.6</td>
<td>15.4</td>
<td>20.0</td>
</tr>
<tr>
<td>% HADS anxiety ≥8</td>
<td>39.1</td>
<td>35.4</td>
<td>30.8</td>
</tr>
</tbody>
</table>
Some foods are consumed in a significantly lesser amount by IBS patients compared to controls, such as products that contain fibers. We applied the user analysis to investigate food products which may be avoided by IBS patients. Food products identified in the user analysis are similar to those described in the studies reporting on foods evoking GI symptoms, including apples, peanuts, onion, whole wheat bread, coffee, citrus fruits, and milk.\(^1\)\(^3\)

The major strength of our study is that we evaluated habitual dietary intake using a standardized FFQ in a relatively large sample of clinically diagnosed, well characterized IBS patients and we included a score for overall diet quality. It has to be noted that the micronutrient intake could not be quantified in this study. However, the results of the mean intake and user analysis of food groups and food products in IBS patients do provide clues which micronutrients might be deficient. The reduced intake of cereals and wheat products could, apart from the lower fiber intake, lead to an inadequate intake of B-vitamins and iron, while limited consumption of fruit and dairy products could lead to inadequate vitamin C and calcium intake. A limitation of our study is the difference in gender distribution, smoking and BMI; the control group included more men, fewer smokers and had a lower BMI. As all analyses were adjusted for gender, age, energy intake, and smoking differences, we expect that these differences have not had a major impact on our findings. Moreover, post hoc adjustment for BMI did not influence the outcomes. Interestingly, while the mean BMI was higher, the overall energy intake of IBS patients was lower compared to healthy controls. This may be explained by factors not measured in this study, such as decreased physical activity in the IBS population. Previous studies have indicated that IBS patients tend to be less physically active compared to controls.\(^48\)\(^49\)

With regard to the used FFQ, recall bias cannot be excluded. This is a well known limitation of all retrospective questionnaires.\(^50\)\(^51\) However, this extensive questionnaire has demonstrated to be a reliable tool to investigate dietary patterns in different populations in previous studies.\(^30\)\(^37\)\(^38\) Apart from the self-reported adherence to special diets, we have no detailed information on previous dietary consultation by our IBS patients. However, widespread dietary advice by an expert nutritionist was not common practice in regional daily clinical care. Furthermore, although our study included a relative large number of patients, the number of subjects per IBS subtype is still limited. Another limitation of this study is the lack of information on socioeconomic status of the study participants, which could potentially be a confounder. However, previous studies have not shown a relation between socioeconomic status and the prevalence of IBS.\(^52\) As cross-cultural variation in diet may affect differences in nutrient intake between IBS patients and the healthy population, the extrapolation of our data to populations in regions with different dietary habits should be done with care. Finally, it has to be acknowledged that due to the observational design causality has not been investigated in this study.

This study describes the habitual diet and diet quality in a case-control design, comparing IBS patients and healthy controls. Although, diet quality indicators were associated with specific patient phenotypes and some correlation between dietary factors and gastrointestinal symptoms were identified, future studies should investigate the relation between diet and symptoms in more detail. It is important to identify possible aggravating or alleviating factors, which could be of value for clinical care. Interaction between dietary pattern and symptoms may not always be recognized as such by patients and therefore, cannot be reported in retrospective questionnaires. Furthermore, due to the heterogeneity of the IBS population the relation between diet and symptoms differs between patients. A prospective study measuring both symptoms and food intake during everyday life, using momentary assessment methods\(^50\)\(^51\) could provide new insights. Furthermore, as IBS patients tend to turn to self-treatment, often including dietary adaptations, treating physicians should focus on diet during history taking and if indicated diet quality should be warranted by education of patients via dietitians or nutritionists.

## 5 | CONCLUSION

Differences in habitual diet of IBS patients and healthy controls were described, with indication of lower overall diet quality in the IBS group, with an increased use of fat and sugar, and lower intake of fiber, which was most pronounced in diarrhea predominant IBS patients. Our data supports the importance of personalized and professional nutritional guidance of IBS patients, with among others focus on diet quality.

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## CONFLICT OF INTEREST

No competing interests declared.

## AUTHOR CONTRIBUTIONS

EF and ZM wrote the manuscript, DJ, EF, AM, CW, and ET were involved in the conception and design of the study. ET, ZM, AZ, MH, SM, and CP contributed to data collection. ET, ZM, AZ, EF, and JD were involved in data analysis and interpretation. DJ had primary responsibility for the final content. All authors have critically revised this article and approved the final version to be published.

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