Title page

Dietary behaviors in relation to prevalence of irritable bowel syndrome in adolescent girls

Running title: Diet-related practice and IBS

Sayyed Saeid Khayyatzadeh[1], Seyyed Mohammad Reza Kazemi-Bajestani[2, 3], Seyed Jamal Mirmousavi[4], Masoud Heshmati[5], Somaieh Khoshmohabbat[6], Gordon A. Ferns[7], Majid Ghayour-Mobarhan[6, 7]

[1]Student research committee, Department of Nutrition, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[2]Cardiovascular Research Center, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

[3]Department of Oncology, Division of Palliative Care Medicine, University of Alberta, Edmonton, Alberta, Canada

[4]Community Medicine, Community Medicine Department, Medical School, Sabzevar University of Medical Sciences, Sabzevar, Iran.

[5]Department of immunology and microbiology, Faculty of Medicine, Shahrekord University of Medical Sciences, Shahrekord, Iran.

[6]Metabolic Syndrome Research Center, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

[5]Brighton & Sussex Medical School, Division of Medical Education, Falmer, Brighton, Sussex BN1 9PH, UK

[7]Department of Modern Sciences and Technologies, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

*** Corresponding Author:**
Majid Ghayour-Mobarhan MD, PhD, Biochemistry of Nutrition Research Center, School of Medicine, Mashhad University of Medical Sciences, 99199-91766, Mashhad, Iran; Tel:+985138002288, Fax: +985138002287;
Email: ghayourm@mums.ac.ir; ghayourmobarhan@yahoo.com
Word count: 3118

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/jgh.13908

Abstract

BACKGROUNDS AND AIMS: There is limited evidence regarding the relationship between dietary behaviors and irritable bowel syndrome (IBS). This study aimed to explore the association between diet-related practices and prevalence of IBS.

METHODS: The study was conducted among 988 adolescent girls living in Iran. Dietary behaviors were pre-defined and assessed in nine domains using a pre-tested questionnaire. To investigate the association between diet-related practices and the presence of IBS, we used logistic regression analysis in crude and adjusted models.

RESULTS: The prevalence of IBS was 16.9% in this population. Compared with individuals who did not consume fluid with their meal, those who always consumed fluid with meals had a greater chance of IBS (OR: 2.91; *P*: 0.01). We found a direct relationship between a greater intake of spicy food and IBS prevalence (OR: 5.28; *P*: 0.02). The individuals who ate fried foods every day also had a greater risk of IBS compared with those who did not consume fried foods (OR: 1.65; P: 0.01). The subjects who had lost ≥5 teeth had 2.23 times greater odds for IBS than the individual who had lost ≤1 tooth (OR: 2.23; P: 0.01) was a significant inverse relationship between the chewing sufficiency and the risk of IBS (OR: 4.04; P: 0.02). These associations remained significant after controlling for potential confounder

CONCLUSIONS: Intra-meal fluid intake, chewing insufficiency, higher tooth loss and the consumption of spicy and fried food were associated with increased risk of IBS. Prospective studies are needed to confirm these findings.

Keywords: irritable bowel syndrome, dietary habits, fluid intake, spicy food, chewing, tooth loss

Introduction

Irritable bowel syndrome (IBS) is the most prevalent functional gastrointestinal disorder (FGID) which is characterized by abdominal pain, distension and altered bowel habits (1). Work performance and quality of life are affected by the presence of IBS (2). Globally, the prevalence of IBS has been reported to be approximately 5-20 % (3, 4) in adults and 2-24% in children (5). The presence of IBS may be diagnosed at a young age (6) and its prevalence is 1.8 times higher in girls compared to boys (7). Diet along with psychological disorders, antibiotic use and overuse of laxatives all appear to have causative relationships with IBS (8).

Moreover, both nutrient intake and dietary patterns are known to be associated with the risk of IBS (9-11). A high dietary intake of carbohydrate, caffeine, alcohol, fried foods and fast foods are connected to development of IBS (11-13). Despite the role of diet in IBS management, eating behaviors also seem to be an important contributor to IBS. However, little information is available about the relationship between adherence to specific dietary behaviors and this syndrome. The intake of main meals, and snacks, meal regularity, breakfast skipping, chewing insufficiency, spicy and fried food consumption are considered as important dietary determinants of IBS. Sun et al. found that skipping breakfast is associated with increased risk of gastrointestinal disease (14), whilst findings from a large cross-sectional study in China did not confirm this finding (15). Patients with IBS have been shown to have a greater likelihood of irregular and skipped meals compared to non-IBS subjects (16). Consumption of spicy foods containing saffron, turmeric, ginger or cumin, is a feature of the traditional diet in Iran (17). There is some evidence indicating a link between the intake of spicy foods and increased risk of IBS (18), although there is inconsistency in these reports (19, 20). Tooth loss is a common cause of impaired masticatory function. Insufficient masticatory function has been reported to increase the risk of gastrointestinal diseases (21).

The role of dietary behaviors that may contribute to IBS has received little attention in epidemiological studies, and there are no reports on the relationship between dietary behavior profiles and IBS in adolescent girls. Given the high prevalence of IBS and potential importance of eating behaviors, we aimed to determine the association between the important dietary behaviors and IBS in a large group of Iranian adolescent girls.

Methods

Study population

This study was conducted in the cities of Mashhad and Sabzevar, in northeastern Iran in January 2015. The participants were selected by using a randomized clustering method among adolescent girls. We excluded girls with any chronic diseases or subjects who were taking drugs or supplements within the last 6 months. A total of 1026 adolescents aged 12-18 y old were screened; of whom, 988 met the inclusion criteria. Written consent was obtained from all students and their parents. The ethical committee of Mashhad University of Medical Sciences approved the study.

Demographic and anthropometric assessments

Demographic data was collected by face-to-face interview, using a standard questionnaire. Passive smoking status (yes/no) and menstruation status (yes/no) were assessed during the interview. Physical activity was assessed using a validated questionnaire (22) and provided as metabolic equivalents (METs) in hours per day. Anthropometric parameters (waist circumference, weight, height) and cardiac measurements were determined by validated instruments and standard protocol in health centers, by trained paramedic.

Dietary assessment

A validated food frequency questionnaire was used for evaluating dietary intakes during the year (23, 24). To estimate energy and nutrient intakes, the reported portion size in the food

frequency questionnaire (FFQ) and dietary records were converted to grams using household measures and then were entered to the Nutritionist 4 software Nutritionist IV software.

Dietary behaviors assessment

Based on earlier studies (25-27), dietary behaviors were defined in nine domains (main meal patterns, breakfast intake, snack intake, meal regularity, intra-meal fluid intake, spicy food intake, fatty food intake, chewing insufficiency and lack of teeth) using a self-administered questionnaire.

To investigate meal frequency, we asked the participants to answer the following questions: "How many main meals do you consume each day?" and "How many snacks do you consume each day?" They could respond to the first question by choosing one of these choices: one, two, or three. The second question could be responded to by selecting one of these choices: none, one to two, three or more than three. Meal pattern regularity was assessed by asking individuals about the regularity of their meals "Do you consume your meals regularly?" The subjects were able to answer through these choices: never, sometimes, almost, or always. We also asked about the regularity of having breakfast: never or 1 day/week, 2–4 days/week, 5–6 days/ week, daily).

Intra-meal fluid drinking was investigated through questions about drinking water or fluids with meals or immediately before and after meals (never, sometimes, often, and always). With regard to fried and spicy food intake, participants were asked to report how many days per week these types of food were consumed. "How often do you have spicy foods (chili pepper, curry, ginger, cinnamon, and turmeric) during a week?" Participants could respond to this question by selecting one of the following choices: never, 1-3 times, 4-6 times, 7 or more than 7 times per week. Responses to this question were used as the main exposure variable in the current study.

Quality of chewing was evaluated by the following question: How thoroughly do you chew food? Answers were no problem, just soft and pasty foods, no food. Tooth loss was evaluated by asking participants the following question: "How many teeth have you lost?" The subject were able to select one of these choices: "≤ one tooth loss," "2-4 teeth loss" and "five teeth loss".

Assessment of irritable bowel syndrome

To assess the presence of IBS, we used a version of the Rome III questionnaire translated into Persian, as a part of original questionnaire in order to assess for Functional gastrointestinal disorders (FIGDs). This questionnaire has been validated previously (28). Participants were also asked about the presence of each Rome III-defined symptom in the previous three months. IBS was defined according to Rome III criteria as recurrent abdominal pain or discomfort at least sometimes in the previous 3 months associated with two or more of the following criteria: (1) improvement with defecation at least sometimes; (2) pain onset associated with a change in stool frequency; and (3) pain onset associated with a change in stool form at least sometimes.

Statistical analyses

Comparisons of continuous data in subjects with and without IBS were assessed using independent sample t-test. Chi-square test was used to examine the distribution of categorical variables between IBS patients and healthy subjects. To find the association between diet-related practices and IBS prevalence, we used logistic regression in different models. Initially using an uncorrected model, and then adjusted for age, menstruation and energy intake (Kcal/day). Further adjustments were done for physical activity, passive smoking and BMI. A P-value <0.05 was considered statistically significant. All statistical analyses were performed

by using statistical Package for Social Sciences version 24 (SPSS Inc., Chicago, Illinois, USA).

Results

The prevalence of IBS was 16.9% (n = 167 of 988 girls) in our population sample. The descriptive characteristics of healthy subject and IBS patients are shown in **Table 1**. No significant differences were obtained for means of age, weight, BMI, waist circumference and SBP between individuals with and without IBS. The level of diastolic blood pressure was significantly lower in IBS patients compared to healthy subjects. We did not find any significant differences in the distribution of categorical variables (menstruation and passive smoking) in IBS and non-IBS subjects.

Significant differences were observed for intake of soluble dietary fiber, fruits, fried food, soft drinks and spices between subjects with and without IBS. Higher intakes of soluble dietary fiber and fruits were observed in healthy subjects; while we found a higher intake of caffeine, spices, soft drinks and fried food in IBS patients compared with healthy subjects.

General characteristics of study participants across categories of dietary behaviors are indicated in **Table 2**. A significant statistical difference was seen among categories of snack intake, fried food intake and chewing insufficiency for IBS prevalence. There was a higher prevalence of IBS in individuals who had a high consumption of fried food. The subjects with a lack of dentition had a higher prevalence of IBS. The highest prevalence of IBS was found in subjects with the greatest problems with chewing. We did not find any significant differences across categories of main meal intake, meal regularity, breakfast intake, spicy food intake and intra-meal fluid intake for IBS prevalence.

Multivariate-adjusted odds ratios for IBS across categories of diet-related behaviors are presented in **Table 3**. Compared with those who never consumed intra-meal fluid, individuals who always consumed intra-meal fluid had a greater risk for IBS (OR: 2.91; 95% CI: 1.19-

7.11; *P*: 0.01); after adjustments for potential confounders, this relationship remained significant. There was also a significant direct relationship between greater intake of spicy foods intake and IBS prevalence (OR: 5.28; 95% CI: 1.67- 8.1; *P*: 0.02). Again this association remained significant after further adjustments. The individuals who ate fried foods every day tended to have greater odds for IBS compared with those who did not consume fried foods (OR: 1.65; 95% CI: 1.5- 5.34; *P*: 0.01). This relationship remained significant after adjustments for confounding factors. The subjects who had lost ≥5 teeth had 2.23 times greater odds for IBS than the individual who had lost ≤1 teeth (OR: 2.23; 95% CI: 1.18- 4.23; P: 0.01). There was a significant positive relationship between a lower chewing sufficiency (in individuals who did not chew all foods) and the risk of IBS (OR: 4.04; 95% CI: 1.89- 8.45; *P*: 0.0.2. Also, after controlling for different confounders, this association remained significant.

Neither in the crude, nor adjusted models, were there significant associations between other diet-related practices (main meal intake, snack intake, meal regularity and breakfast intake) and IBS prevalence.

Discussion

In this cross-sectional study we have found that the higher intake of fluid with meals was positively associated with IBS among Iranian adolescent girls. A greater frequency in consumption of fried and spicy food was related to an increased risk of IBS. We found that chewing insufficiency was directly associated with IBS prevalence. In addition, there was a positive association between tooth loss and IBS prevalence. We observed no significant association between mail meal intake, snack intake, meal regularity and breakfast intake with IBS in this study. To the best of our knowledge, the current study is among the first population-based studies that examined diet-related practices and IBS in adolescents.

Irritable bowel syndrome is the most common functional gastrointestinal disorder characterized by chronic or recurrent abdominal pain associated with altered bowel habits. IBS is considered to be a life-long disease and its treatment remains a challenge. Like other chronic diseases, "management and control" rather than "treatment" is more appropriate description for IBS. However, there may be self-management strategies for IBS that may be an effective alternative to improve IBS and its symptoms. Therefore, it is necessary to identify potential factors involved in the etiology of IBS which can increase our ability in self-management of this syndrome (29). We conducted a large cross-sectional study to examine the association between adherence to diet-related practice and IBS. The findings from the present study showed that dietary behaviors and diet-related practices should receive more attention in relation to IBS.

There are few data on the relationship between habitual intake of spicy foods and prevalence of IBS. Most studies have assessed the effects of pepper intake on improvement of IBS symptoms (30-32). In the present study, there was a direct association between a high consumption of spicy foods and risk of IBS. This finding is in line with a large cross-sectional study, which revealed a significant relationship between a high habitual spicy food intake and the prevalence of IBS in Iranian adults (18). A direct relationship between the consumption of pepper and the prevalence of IBS was also shown in population based study in China (13). Gonlachanvit et al. showed the consumption of 2 g chili in a standard meal or separately in capsules was related to increased symptoms in IBS patients compared with healthy subjects (33). In contrast, some other studies have indicated that the intake of spices may be associated with alleviation of symptoms in IBS patients. Abdominal pain and bloating were significantly improved in IBS patients who received 150 mg of red pepper pill extract for 6 weeks (20). Beneficial effects of ginger, cinnamon and turmeric on IBS symptoms have also been reported in several studies (30-32). There are some potential reasons that may

explain this inconsistency of results in relation with effects of spices on IBS symptoms. Methodology and study designs may be important reasons for these differences. Most of studies assessed effects of high doses of individual spices in the form of meal or supplements on IBS symptom. In the current study, we observed that habitual intake of spicy foods is related to IBS; but, we did not distinguish between consumption of the different individual spices and their possible effects. The mechanisms through which the intake of spicy foods might affect IBS are not understood. Capsaicin is the main ingredient of red pepper which might intensify the symptoms of IBS through modifying gastrointestinal sensation via transient potential vanilloid 1 (TRPV1) receptors (19, 33). An increased intake of capsaicin can lead to up-regulation of TRV1, which might associate with visceral hypersensitivity in the proximal gut and colon. In turn, recent small studies reported that chronic intake of capsaicin-containing chili can reduce the symptom of FGIDs (19).

We found that the consumption of fried food was directly related to an increased prevalence of IBS among Iranian adolescents. Our finding was similar to a large cross-sectional study in China which indicated fried food eating was positively linked to IBS in children (34). In a recent study, IBS patients reported which intake of fried and fatty foods made their gastrointestinal (GI) symptoms worse (35). The underlying mechanism by which fatty and fried food intensify the symptoms of IBS may be related to increased gas retention, GI sensitivity and exaggerated gastro-colonic response (36). IBS patient then suffers from bloating, abdominal pain, distention and other symptoms (37). Therefore, it is advised that the IBS patients should avoid the consumption of foods rich in fat in order to reduce these symptoms (38).

We observed an association between tooth loss and risk of IBS. In addition, we found chewing insufficiency was related to higher prevalence of IBS. Although some data are available on the relation between FGIDS and dental status, we have only found one study that

has investigated the association between dental status and IBS. Esmaillzadeh et al. reported that losing 1-2 or 3-5 teeth might be associated with higher prevalence of IBS (39). Reduced levels of gastrointestinal pathologies is found in subjects with a natural set of teeth compared to others (21). Several studies have revealed that inadequate masticatory and chewing function significantly increased the risk of gastrointestinal disorders (21, 40, 41). Insufficient chewing, decreased breakdown of food and reduced exposure to saliva might be related to inadequate gastric secretion, impaired bolus formation and consequent digestive disorders (42). Poor mastication and swallowing foods is also associated with reduced autonomic nervous activity, resulting in impaired gastric motor and excretion function (43). Tooth loss and chewing problems could possibly contribute a reduced consumption of fresh fruits and vegetables (43, 44). Further research is needed to clarify the potential mechanisms in relation to effects of tooth loss and chewing complications on IBS.

We found, a significant association between a high consumption of intra-meal fluid and risk of IBS. So far, this is the first report demonstrating the relationship between chronic and intermittent intake of fluid-intra meal and the prevalence of IBS. However, Zuo et al. reported that an intake of cold water leads to a reduced visceral perception threshold in IBS patient compared with control group. This may be inversely related to abdominal symptoms. However, they did not found any change in perception threshold after intake of warm water in IBS patients or control group (45). These results were confirmed by a cross-sectional study on 256 women with urinary incontinence; increased total daily fluid intake was significantly related to bothersome bowel movements (46). On other hand, several studies suggested high and abnormal accumulation of intestinal fluid following impairment in water absorption or increased secretion was related to IBS symptoms. The possible underlying mechanisms is not clear yet. Although, we did not separate fluid intake by its temperature in questionnaire, it is likely that most Iranian people consume cold water with meals.

Intake of cold water is significantly associated with stimulation of the cold-sensitive thermal-receptors (ANKTM1 and TRPM8) and visceral afferents in the stomach and as a result affect gastrointestinal function through afferent and efferent pathways (47). Also cold fluid consumption might increase 5-hydroxytryptamine (5-HT) secretion, that causes a disturbance in gastrointestinal function (48, 49).

There are some strength points for our study. To the best our knowledge, it is first study which examine the relationship between adherence to specific dietary behaviors and prevalence of IBS. High quality of data collection was second strength point in the current study. In third, we conducted rigorous statistical analyses, including several adjustment models for confounding factors to IBS. Nevertheless, our findings require to be interpreted by considering some potential limitations. Major limitation is related to cross-sectional design of the study; therefore, we do not suggest a causal relationship. In addition, it is more likely to exist recall bias in cross-sectional studies due to low response and misclassification. Also the current study was performed only on girls and not boys that this might be a limitation.

Conclusion

In summary, the results of current study demonstrated direct associations between intra-fluid intake, spicy and fried foods consumption, tooth loss and chewing problems with prevalence of IBS both in crude and adjusted models. We are unable to confirm any significant association between breakfast intake, meal regularity, main meal and snack intake with IBS prevalence either in crude or adjusted models. Further studies, in particular of a prospective nature, are needed to examine the associations between adherence to specific diet-related practices and risk of IBS and other FGIDs.

Acknowledgments

This article was derived from a PhD thesis written by first author (Code: 940983). We sincerely thank all students participating in this study because this study would not be possible without their cooperation. We also extend our appreciation to those who helped us in every way possible in this study. This work was financially supported by the Mashhad University of Medical Sciences Foundation.

Conflicts of interest

All authors state that they have no conflicts of interest.

References

1. Khan S, Chang L. Diagnosis and management of IBS. Nature Reviews Gastroenterology and Hepatology. 2010;7(10):565-81.
2. Varni JW, Lane MM, Burwinkle TM, Fontaine EN, Youssef NN, Schwimmer JB, et al. Health-Related Quality of Life in Pediatric Patients with Irritable Bowel Syndrome:: A Comparative Analysis. Journal of Developmental & Behavioral Pediatrics. 2006;27(6):451-8.
3. Choi M-G, Jung H-K. Health related quality of life in functional gastrointestinal disorders in Asia. J Neurogastroenterol Motil. 2011;17(3):245-51.
4. Camilleri M. Peripheral mechanisms in irritable bowel syndrome. New England Journal of Medicine. 2012;367(17):1626-35.
5. Devanarayana NM, Mettananda S, Liyanarachchi C, Nanayakkara N, Mendis N, Perera N, et al. Abdominal pain–predominant functional gastrointestinal diseases in children and adolescents: prevalence, symptomatology, and association with emotional stress. Journal of pediatric gastroenterology and nutrition. 2011;53(6):659-65.
6. Jahangiri P, Jazi MSH, Keshteli AH, Sadeghpour S, Amini E, Adibi P. Irritable bowel syndrome in Iran: SEPAHAN systematic review No. 1. International journal of preventive medicine. 2012;3(3S).
7. Dong L, Dingguo L, Xiaoxing X, Hanming L. An epidemiologic study of irritable bowel syndrome in adolescents and children in China: a school-based study. Pediatrics. 2005;116(3):e393-e6.
8. Halpert A, Dalton CB, Palsson O, Morris C, Hu Y, Bangdiwala S, et al. What patients know about irritable bowel syndrome (IBS) and what they would like to know. National Survey on Patient Educational Needs in IBS and development and validation of the Patient Educational Needs Questionnaire (PEQ). The American journal of gastroenterology. 2007;102(9):1972-82.
9. Böhn L, Störsrud S, Simrén M. Nutrient intake in patients with irritable bowel syndrome compared with the general population. Neurogastroenterology & Motility. 2013;25(1):23-e1.
10. Chey WD, Kurlander J, Eswaran S. Irritable bowel syndrome: a clinical review. Jama. 2015;313(9):949-58.
11. Khayyatzadeh S, Esmaillzadeh A, Saneei P, Keshteli A, Adibi P. Dietary patterns and prevalence of irritable bowel syndrome in Iranian adults. Neurogastroenterology & Motility. 2016;28(12):1921-33.
12. Williams EA, Nai X, Corfe BM. Dietary intakes in people with irritable bowel syndrome. BMC gastroenterology. 2011;11(1):9.

13. Zhou H, Li D, Song Y, Zong C, Hu Y, Xu X, et al. Risk factors of irritable bowel syndrome in adolescents in China. Zhonghua er ke za zhi= Chinese journal of pediatrics. 2008;46(2):136-8.
14. Sun J, Yi H, Liu Z, Wu Y, Bian J, Wu Y, et al. Factors associated with skipping breakfast among Inner Mongolia Medical students in China. BMC public health. 2013;13(1):42.
15. Wang Y, Jin F, Chi B, Duan S, Zhang Q, Liu Y, et al. Gender differences in irritable bowel syndrome among medical students at Inner Mongolia Medical University, China: a cross-sectional study. Psychology, health & medicine. 2016;21(8):964-74.
16. Okami Y, Kato T, Nin G, Harada K, Aoi W, Wada S, et al. Lifestyle and psychological factors related to irritable bowel syndrome in nursing and medical school students. Journal of gastroenterology. 2011;46(12):1403-10.
17. Azadbakht L, Esmaillzadeh A. Macro and micro-nutrients intake, food groups consumption and dietary habits among female students in Isfahan University of Medical Sciences. Iranian Red Crescent Medical Journal. 2012;2012(4, Apr):204-9.
18. ESMAILLZADEH A, HASANZADEH KA, HAJISHAFIEE M, FEIZI A, FEINLE BC, ADIBI P. CONSUMPTION OF SPICY FOODS AND THE PREVALENCE OF IRRITABLE BOWEL SYNDROME. 2014.
19. Gonlachanvit S. Are rice and spicy diet good for functional gastrointestinal disorders? J Neurogastroenterol Motil. 2010;16(2):131-8.
20. Bortolotti M, Porta S. Effect of red pepper on symptoms of irritable bowel syndrome: preliminary study. Digestive diseases and sciences. 2011;56(11):3288-95.
21. Tosello A, Foti B, Sedarat C, Brodeur J, Ferrigno J, Tavitian P, et al. Oral functional characteristics and gastrointestinal pathology: an epidemiological approach. Journal of oral rehabilitation. 2001;28(7):668-72.
22. Delshad M, Ghanbarian A, Ghaleh NR, Amirshekari G, Askari S, Azizi F. Reliability and validity of the modifiable activity questionnaire for an Iranian urban adolescent population. International journal of preventive medicine. 2015;6(1):3.
23. Asghari G, Rezazadeh A, Hosseini-Esfahani F, Mehrabi Y, Mirmiran P, Azizi F. Reliability, comparative validity and stability of dietary patterns derived from an FFQ in the Tehran Lipid and Glucose Study. British journal of nutrition. 2012;108(06):1109-17.
24. Hosseini Esfahani F, Asghari G, Mirmiran P, Azizi F. Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. Journal of epidemiology. 2010;20(2):150-8.
25. Galhardo J, Hunt L, Lightman S, Sabin M, Bergh C, Sodersten P, et al. Normalizing eating behavior reduces body weight and improves gastrointestinal hormonal secretion in obese adolescents. The Journal of Clinical Endocrinology & Metabolism. 2012;97(2):E193-E201.
26. Ohkuma T, Fujii H, Iwase M, Kikuchi Y, Ogata S, Idewaki Y, et al. Impact of eating rate on obesity and cardiovascular risk factors according to glucose tolerance status: the Fukuoka Diabetes Registry and the Hisayama Study. Diabetologia. 2013;56(1):70-7.
27. Brewer EA, Kolotkin RL, Baird DD. The relationship between eating behaviors and obesity in African American and Caucasian women. Eating behaviors. 2003;4(2):159-71.
28. Sorouri M, Pourhoseingholi MA, Vahedi M, Safaee A, Moghimi-Dehkordi B, Pourhoseingholi A, et al. Functional bowel disorders in Iranian population using Rome III criteria. Saudi Journal of Gastroenterology. 2010;16(3):154.
29. Dorn SD. Systematic review: self-management support interventions for irritable bowel syndrome. Alimentary pharmacology & therapeutics. 2010;32(4):513-21.
30. Hawrelak JA, Myers SP. Effects of two natural medicine formulations on irritable bowel syndrome symptoms: a pilot study. The Journal of Alternative and Complementary Medicine. 2010;16(10):1065-71.
31. Bundy R, Walker AF, Middleton RW, Booth J. Turmeric extract may improve irritable bowel syndrome symptomology in otherwise healthy adults: a pilot study. Journal of Alternative & Complementary Medicine. 2004;10(6):1015-8.

32. Van Tilburg MA, Palsson OS, Levy RL, Feld AD, Turner MJ, Drossman DA, et al. Complementary and alternative medicine use and cost in functional bowel disorders: a six month prospective study in a large HMO. BMC Complementary and Alternative Medicine. 2008;8(1):46.
33. Gonlachanvit S, Mahayosnond A, Kullavanijaya P. Effects of chili on postprandial gastrointestinal symptoms in diarrhoea predominant irritable bowel syndrome: evidence for capsaicin-sensitive visceral nociception hypersensitivity. Neurogastroenterology & Motility. 2009;21(1):23-32.
34. Zhu X, Chen W, Zhu X, Shen Y. A cross-sectional study of risk factors for irritable bowel syndrome in children 8–13 years of age in Suzhou, China. Gastroenterology research and practice. 2014;2014.
35. Böhn L, Störsrud S, Törnblom H, Bengtsson U, Simrén M. Self-reported food-related gastrointestinal symptoms in IBS are common and associated with more severe symptoms and reduced quality of life. The American journal of gastroenterology. 2013;108(5):634-41.
36. Narducci F, Bassotti G, Granata MT, Pelli MA, Gaburri M, Palumbo R, et al. Colonic motility and gastric emptying in patients with irritable bowel syndrome effect of pretreatment with octylonium bromide. Digestive diseases and sciences. 1986;31(3):241-6.
37. Ringel Y, Williams RE, Kalilani L, Cook SF. Prevalence, characteristics, and impact of bloating symptoms in patients with irritable bowel syndrome. Clinical Gastroenterology and Hepatology. 2009;7(1):68-72.
38. McKenzie Y, Alder A, Anderson W, Wills A, Goddard L, Gulia P, et al. British Dietetic Association evidence-based guidelines for the dietary management of irritable bowel syndrome in adults. Journal of Human Nutrition and Dietetics. 2012;25(3):260-74.
39. Esmaillzadeh A, Keshteli A, Saneei T, Saneei P, Savabi O, Adibi P. Is tooth loss associated with irritable bowel syndrome? Journal of oral rehabilitation. 2015;42(7):503-11.
40. Pera P, Bucca C, Borro P, Bernocco C, De Lillo A, Carossa S. Influence of mastication on gastric emptying. Journal of dental research. 2002;81(3):179-81.
41. Altenhoevel A, Norman K, Smoliner C, Peroz I. The impact of self-perceived masticatory function on nutrition and gastrointestinal complaints in the elderly. The journal of nutrition, health & aging. 2012;16(2):175-8.
42. Proff P. Malocclusion, mastication and the gastrointestinal system. Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie. 2010;71(2):96-107.
43. Kimura Y, Nomura M, Sawada Y, Muraoka N, Kohno N, Ito S. Evaluation of the effects of mastication and swallowing on gastric motility using electrogastrography. The Journal of Medical Investigation. 2006;53(3, 4):229-37.
44. Kazemi S, Savabi G, Khazaei S, Savabi O, Esmaillzadeh A, Hassanzadeh Keshteli A, et al. Association between food intake and oral health in elderly: SEPAHAN systematic review no. 8. Dental research journal. 2012;8(5).
45. Zuo XL, Li YQ, Shi L, Lv GP, Kuang RG, Lu XF, et al. Visceral hypersensitivity following cold water intake in subjects with irritable bowel syndrome. Journal of gastroenterology. 2006;41(4):311-7.
46. Segal S, Saks EK, Asfaw TS, Arya LA. Increased fluid intake is associated with bothersome bowel symptoms among women with urinary incontinence. Female pelvic medicine & reconstructive surgery. 2013;19(3):152.
47. Zhang L, Jones S, Brody K, Costa M, Brookes SJ. Thermosensitive transient receptor potential channels in vagal afferent neurons of the mouse. American Journal of Physiology-Gastrointestinal and Liver Physiology. 2004;286(6):G983-G91.
48. Spiller RC. Effects of serotonin on intestinal secretion and motility. Current opinion in gastroenterology. 2001;17(2):99-103.
49. Davidson H, Pilot M, editors. Does endogenous neuronal 5-hydroxytryptamine influence canine intestinal motility. JOURNAL OF PHYSIOLOGY-LONDON; 1986: CAMBRIDGE UNIV PRESS 40 WEST 20TH STREET, NEW YORK, NY 10011-4211.

Table 1. Descriptive characteristics of study participants by IBS presence

	IBS presence		P-value†
	healthy (n=821)	Patients (n=167)	
Demographic and anthropometric data			
Age, y	14.6±1.5	14.3±1.4	0.05
Passive smoking (%)	32	37	0.15
Menstruation (%)	88.9	82.5	0.07
Physical activity (MET.h/day)	45.3±3.3	45.03±4.2	0.23
BMI, kg/m^2	21.2±4.3	20.9±4.2	0.29
WC, cm	70.3±9.06	70.3±9.6	0.97
SBP, mmHg	96.8±14.4	94.8±13.6	0.07
DBP, mmHg	63.06±13.6	59.6±12.5	0.01
Nutrient and food groups intake			
Energy (Kcal)	2708±838	2732±839	0.73
Total fat (g/day)	102.3±41.07	105.4±41.7	0.38
Total carbohydrate (g/day)	371.2±121.4	370.8±127.7	0.96
Protein (g/day)	91.8±31.1	91.5±30.3	0.92
Soluble dietary fiber (g/day)	0.41±0.35	0.35±0.27	0.02
Insoluble dietary fiber (g/day)	2.1±1.59	1.89±1.29	0.09
Whole grain (g/day)	202.7±177.8	212.3±176.3	0.41
Refined grain (g/day)	288±185.1	283.4±190	0.58
Fruits (g/day)	216.3±138.7	180.5±134.1	0.01
Fried food (g/day)	28.3±22.5	33.2±21.9	0.03
Red meat (g/day)	13.9±11.3	14.6±12.1	0.66
Vegetables (g/day)	226.3±176.8	237.1±180	0.53
Dairy products (g/day)	416.6±298.1	405.4±303.2	0.7
Soft drinks (g/day)	54.7±33.2	71.2±35.6	0.02
Spices (g/day)	2.64±2.19	3.37±2.02	0.02

† Obtained from independent sample t-test or Chi-square test, where appropriate.

Body mass index (BMI), waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP)

Table 2. Descriptive characteristics of study participants across categories of diet-related practices † (n= 988)

	IBS patients (%)	Age (y)	Passive smoker (% yes)	Menstruation (% yes)	BMI (kg/m^2)	Physical activity (MET.h/day)	Energy intakes (Kcal)
Frequency of main meal intake							
1 time	14.3	14.8±1.6	42.9	91.4	22.4±4.4	45.1±3.2	2598±903
2 times	19.8	14.7±1.6	36.5	87.5	21.4±4.8	45.5±3.9	2663±865
3 times	15.9	14.4±1.4*	31.6	87.8	21.06±4.06	45.5±3.4	2741±8252
Frequency of snack intake							
Never	28.6	14.6±1.4	48.1	76.9	21.08±3.9	45.7±4.05	2476±810
1-2 times	13.9	14.6±1.5	32	89.3	21.6±4.5	45.4±3.3	2648±840
≥3 times	20.2**	14.4±1.5	33.3**	87.1	20.7±3.8*	45.7±3.9	2874±815***
Regular meal consumption							
Never	21.6	14.4±1.5	41.5	6.4	21.1±3.5	45.4±3.2	2730±879
Sometimes	17.1	14.5±1.5	37.4	11.7	21.2±4.7	45.6±3.9	2741±829
Almost	16.1	14.7±1.5	31	11.2	21.3±3.9	45.3±3.1	2652±860
Always	14.2	14.3±1.5	23.9	15.6	20.9±4.1	45.4±3.6	2770±770
Breakfast intake							
≤1 day	18	14.8±1.5	45.8	88.7	20.9±3.9	45.5±3.6	2633±806
2-4 day	17.6	14.5±1.5	35.8	88.6	21.5±4.6	45.8±3.9	2701±884
5-6 day	19	14.5±1.5	32.6	88.9	20.4±3.5	45.6±3. 6	2714±786

Every day	15	14.4±1.5	37.4	86.6	21.3±4.3	45.3±3.3	2742±833
Intra-meal fluid intake							
Never	9.8	14.7±1.5	20.8	88.7	21.7±4.2	44.7±2.4	2737±888
Sometimes	13.4	14.4±1.5	31.4	89.5	21.1±4.3	45.4±3.6	2688±861
Almost	18	14.5±1.5	34.6	85	21.6±4.8	45.2±3.2	2670±850
Always	19.7	14.6±1.5	35.9	88	20.8±3.6	46.04±4*	2798±783
Frequency of fried food intake							
Never	14.3	14.5±1.5	25	85.7	21.6±4.9	45.2±4.3	2583±945
1-3 in week	18.5	14.6±1.5	30.3	88.4	21.3±4.2	45.5±3.5	2635±812
4-6 in week	20.3	14.4±1.5	38.8	85.7	20.6±4.06	45.6±3.7	2896±871
Every day	27.3*	14.2±1.3	44.4*	91.1	21.8±5.5	54.4±3.02	2921±841***
Frequency of spicy food intake							
Never	4.8	14.1±1.5	20.8	75	21.2±5.01	44.9±2.6	2748±1096
1-3 in week	15.5	14.6±1.6	34.1	86	21.2±4.08	45.7±3.7	2658±794
4-6 in week	16.3	14.5±1.4	31.5	88.7	21.2±4.6	45.3±3.2	2707±836
≤7 in week	19.5	14.5±1.5	35.5	88.5	21.06±4.03	45.6±3.9	2776±864
Chewing sufficiency							
Yes. No problem	16	14.5±1.5	33.1	87.8	21.2±4.3	45.5±3.6	2721±835
Just soft and pasty foods	27	14.2±1.5	35.5	80.6	20.5±3.7	45.5±3.8	2539±938

	No food	43.3***	16±1.8	60	95	22.1±4.9	46.2±2.1	2765±628
Lack of teeth								
	≤1 tooth	10.9	14.5±1.5	32.9	87.4	21.3±4.3	45.5±3.5	2690±827
	2-4 teeth	16.5	14.7±1.6	41.5	89.2	20.7±4.2	45.5±4.09	2845±896
	≥5 teeth	31*	14.4±1.4	31	88.1	19.9±4.1	45.3±3.2	2840±869

† P-values were obtained from analysis of variance for continuous variables and c2 test for categorical variables.

All values are mean ± SD unless indicated.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3. Multivariable-adjusted odds ratio of the associations between dietary behaviors and IBS prevalence			
Dietary behaviors	**Crude**	**Model I**[+]	**Model II**[‡]
Frequency of main meal intake			
1 time	1	1	1
2 times	1.47 (0.54-4.00)	2.13 (0.61-7.46)	2.41 (0.66-8.81)
3 times	1.13 (0.42-2.98)	1.46 (0.43-4.99)	1.63 (0.45-5.83)
*P trend**	0.87	0.37	0.43
Frequency of snack intake			
Never	1	1	1
1-2	0.4 (0.2-0.78)	0.49 (0.23-1.04)	0.54 (0.24-1.22)
≥3	0.63 (0.32-1.24)	0.71(0.32-1.54)	0.82 (0.36-1.88)
P trend	0.45	0.56	0.4
Meal regularity			
Never	1	1	1
Sometimes	0.95 (0.56-1.61)	0.79 (0.44-1.41)	0.86 (0.47-1.57)
Almost	0.74 (0.43-1.29)	0.7 (0.38-1.28)	0.75 (0.4-1.41)
Always	0.71 (0.39-1.28)	0.69 (0.36-1.34)	0.78 (0.4-1.55)
P trend	0.09	0.26	0.41
Breakfast intake			
Never or 1 day	1	1	1
2-4 day	0.97 (0.56-1.67)	065 (0.35-1.2)	0.6 (0.31-1.14)
5-6 day	1.07 (0.58-1.95)	0.63 (0.31-1.26)	0.51 (0.24-1.07)
Every day	0.8 (0.48-1.35)	0.68 (0.39-1.21)	0.69 (0.38-1.25)
P trend	0.35	0.38	0.47
Intra-meal fluid intake			
Never	1	1	1
Sometimes	1.9 (0.77-4.69)	1.83 (0.74-4.5)	1.69 (0.68-4.24)
Mostly	2.64 (1.08-6.42)	2.58 (1.06-6.31)	2.39 (0.97-5.9)
Always	2.91 (1.19-7.11)	2.86 (1.17-7.01)	2.5 (1.01-6.18)
P trend	0.01	0.02	0.04
Frequency of fried food intake			

	Never	1	1	1
	1-3 in week	1.4 (1.1-1.95)	1.32 (1.05-3.39)	1.44 (1.07-1.91)
	4-6 in week	1.62 (1.12-3.11)	1.7 (1.12 -2.19)	1.59 (1.13-2.88)
	Every day	1.65 (1.5 -5.34)	2.04 (1.53-7.87)	1.63 (1.38-6.71)
	P trend	0.01	0.01	0.03
Frequency of spicy food intake				
	Never	1	1	1
	1-3 in week	3.36 (1.42-6.7)	3.04 (1.38-6.1)	2.63 (1.31-4.1)
	4-6 in week	4.32 (1.55-7.5)	3.63 (1.46-7.4)	2.91 (1.35-4.9)
	7 in week≤	5.28 (1.67-8.1)	4.1 (1.51-7.7)	3.34 (1.39-6.9)
	P trend	0.02	0.03	0.04
Chewing sufficiency				
	Yes. No problem	1	1	1
	Just soft and pasty foods	3.01 (1.9-7.34)	3.88 (1.83-8.2)	3.9 (2.01-9.91)
	No food	4.04(1.89-8.45)	4.72 (2.02-11.03)	4.95 (2.04-12.03)
	P trend	0.02	0.02	0.02
Lack of teeth				
	1 teeth ≥	1	1	1
	2-4 teeth	1.22 (0.53-1.7)	1.19 (0.61-1.59)	1.18 (0.57-1.7)
	≥5 teeth	2.23 (1.18-4.23)	2.25 (1.19-4.27)	2.51 (1.28-4.92)
	P trend	0.01	0.01	0.01

┼Adjusted for age, menstruation and energy intake

╫ Additionally adjusted for passive smoking, physical activity and BMI

* *P* for trend based on logistic regression