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The association between meal and snack frequency and irritable bowel syndrome

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Abstract

Objective: The relationship between daily meal and snack frequency with irritable bowel syndrome (IBS) was less investigated in the literature. We aimed to evaluate this association with IBS symptoms.

Design: A cross-sectional study.

Setting: This investigation was performed in Isfahan, a large province in the centre of Iran. Individuals were asked to complete a self-administered questionnaire to quantify the numbers of daily main meals (one, two or three), snacks (never, 1–2, 3–5 or >5) and the total of them (<3, 3–5, 6–7 or ≥8). IBS and its subtypes were diagnosed according to Rome III criteria.

Participants: General adults (*n* 4669, 2063 men and 2606 women).

Results: The prevalence of IBS was 18·6 % in males and 24·1 % in females. Individuals consuming three main meals had 30 % decreased risk of IBS (OR 0·70, 95 % CI 0·52, 0·94) compared with those with one main meal in the crude model. After adjustments for all potential confounders this relation disappeared (OR 0·67, 95 % CI 0·43, 1·03). Gender-specified analysis revealed that women consuming three main meals per day had 32 % decreased likelihood of having IBS symptoms compared with one daily main meal takers (OR 0·68, 95 % CI 0·47, 0·99). This relation remained significant after adjustment for potential confounders (OR 0·56, 95 % CI 0·36, 0·89). A decreased likelihood of IBS in the highest category of main meal consumption compared with the lowest one was found in obese or overweight subjects (OR 0·54, 95 % CI 0·32, 0·91), after adjustment for all confounders.

Conclusions: Our findings suggested that there was no significant relation between main meal or snack frequency and IBS in Iranian adults, but a small inverse association was found among females and overweight/obese individuals in subgroup analysis. Further prospective studies are needed confirming these associations.

Keywords
Irritable bowel syndrome
Main meal frequency
Snack frequency
Dietary habits
Feeding behaviour

Irritable bowel syndrome (IBS) is the most common functional gastrointestinal (GI) disorder which is characterised by abdominal pain and changes in bowel habits especially in defaecation in the absence of any organic aetiologies[1]. IBS with constipation, IBS with diarrhoea, mixed IBS and un-subtyped IBS are four divisions of the disorder based on defaecation pattern[2]. Although the exact mechanism has not yet been known, genetic problems, psychological factors, gut hypersensitivity, enteric nervous system dysregulation, neurotransmitter imbalance, previous GI infection and low-grade mucosal inflammation are the some suggested possibilities[3,4].

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IBS is more common in females rather than males, and the age of onset is often before 50 years[5]. The prevalence of this disease is different in various regions due to several diagnostic criteria or study design and ranged from 1·1 to 22 % worldwide[6–8]. In Iran, the reported prevalence differed from as low as 1·1 % to as high as 25 %[3]. This syndrome can severely impair patients' quality of life and can cause a great burden on the patient and on healthcare resources. Total cost for people seeking IBS treatment in the USA was annually between $US 1·7 and $US 10 billion[9,10]. Economic burden caused by IBS in Iranian population was estimated to be $US 2·8 million/year[11].

Multiple studies investigating different factors involved in the exacerbation or improvement of IBS symptoms have been performed. For example, diet in low amount of fermentable oligosaccharides, disaccharides, monosaccharides and polyols had been shown to be useful in alleviating symptoms[12]. On the other hand, physical inactivity and insufficient sleep time were reported to play roles in symptom aggravation[13–15]. Eating pattern is one of the most effective parts of dietary behaviours. Several previous investigations have reported the linkage between IBS and dietary habits such as rapid food intake, intra-meal fluid consumption and regularity/irregularity of eating[16–18].

Meal frequency is one of the dietary habits that less investigated its relation with functional GI disorders[19]. Chirila *et al.*[16] have investigated a random sample of 193 Romanian subjects and reported that IBS patients had less meals and snacks than the control group, but this association was not statistically significant. Omagari *et al.*[20] found that among 245 young Japanese women, IBS patients in comparison with healthy individuals skipped their breakfast more often, but this finding was also insignificant. Inadequate sample size and controversial results were some limitations of previous investigations. Also, cultural differences among different populations and diversity in eating behaviours in different countries make us unable to generalise the results of previous investigations to other communities. In the current study, we aimed to evaluate the relationship between meal and snack frequency with IBS symptoms and its subtypes among a large group of Iranian adults.

Methods and materials

Participants

This cross-sectional study was done in the context of Study on the Epidemiology of Psychological, Alimentary Health and Nutrition[21]. The main aim of Study on the Epidemiology of Psychological, Alimentary Health and Nutrition was investigating lifestyle factors with functional GI disorders among general adult population in Isfahan province, Iran. Briefly, the study population consisted of a medical university non-academic staff, including service staff, employees and managers. The socio-economic status of the study population was representative of general Iranian population. As shown in Fig. 1, this project had two phases. In the first phase, self-administered questionnaire on lifestyle, demographic and anthropometric factors was sent to 10 087 subjects, and 8691 of them returned the completed questionnaires. In the second phase, 6236 participants filled questions about their GI profiles. The response rate in these two phases was 86·1 and 61·8 %, respectively. After merging the information of two phases, the complete information of 4669 subjects was available for the current analysis. Data of 1567 individuals could not be used in the analysis, because of incompleteness of questionnaires or identification code in phase 1 or 2 or having missing data in our pre-defined variables.

Assessment of meal frequency

For evaluation of meal frequency, participants were asked to report the numbers of their main meals (one, two or three) and snacks (none, 1–2, 3–5 or >5) consumed per day. Data of total meal and snack frequency were gathered by adding up the total number of main meals and snacks (<3, 3–5, 6–7 or ≥8 per day).

Assessment of irritable bowel syndrome

A modified Persian version of Rome III criteria was used to assess IBS symptoms[6]. Due to the inability of participants to distinguish between measurement scaling of original questionnaire (never, <1 d a month, 1 d a month, 2–3 d a month, 1 d a week, more than 1 d a week and every day), a four-item rating scale was introduced (never or rarely, sometimes, often and always). In addition, 6 months' duration of symptoms was substituted with a period of 3 months[6,21]. IBS was assessed as having abdominal discomfort or pain at least sometimes in the last 3 months prior to the initiation of study along with at least two of the following symptoms: improvement with defaecation and changing in stool form or frequency. Constipation-predominant IBS was defined as having IBS with hard stools and lack of having any watery ones, at least sometimes. Diarrhoea-predominant IBS was defined as having IBS with watery stools at least sometimes and lack of any hard ones. Mixed IBS was defined as having IBS with both of watery and hard stools periodically. Un-subtyped IBS was defined as having IBS with lack of hard or lumpy, loose, mushy or watery stools.

Assessment of other variables

A self-administered questionnaire was used to collect information about age, sex, education level, marital status, smoking and diabetes mellitus. Data of weight (kg) and height (cm) were collected through a self-reported questionnaire. BMI was measured by dividing of weight in kg by height in square of metre (kg/m^2). A validation study

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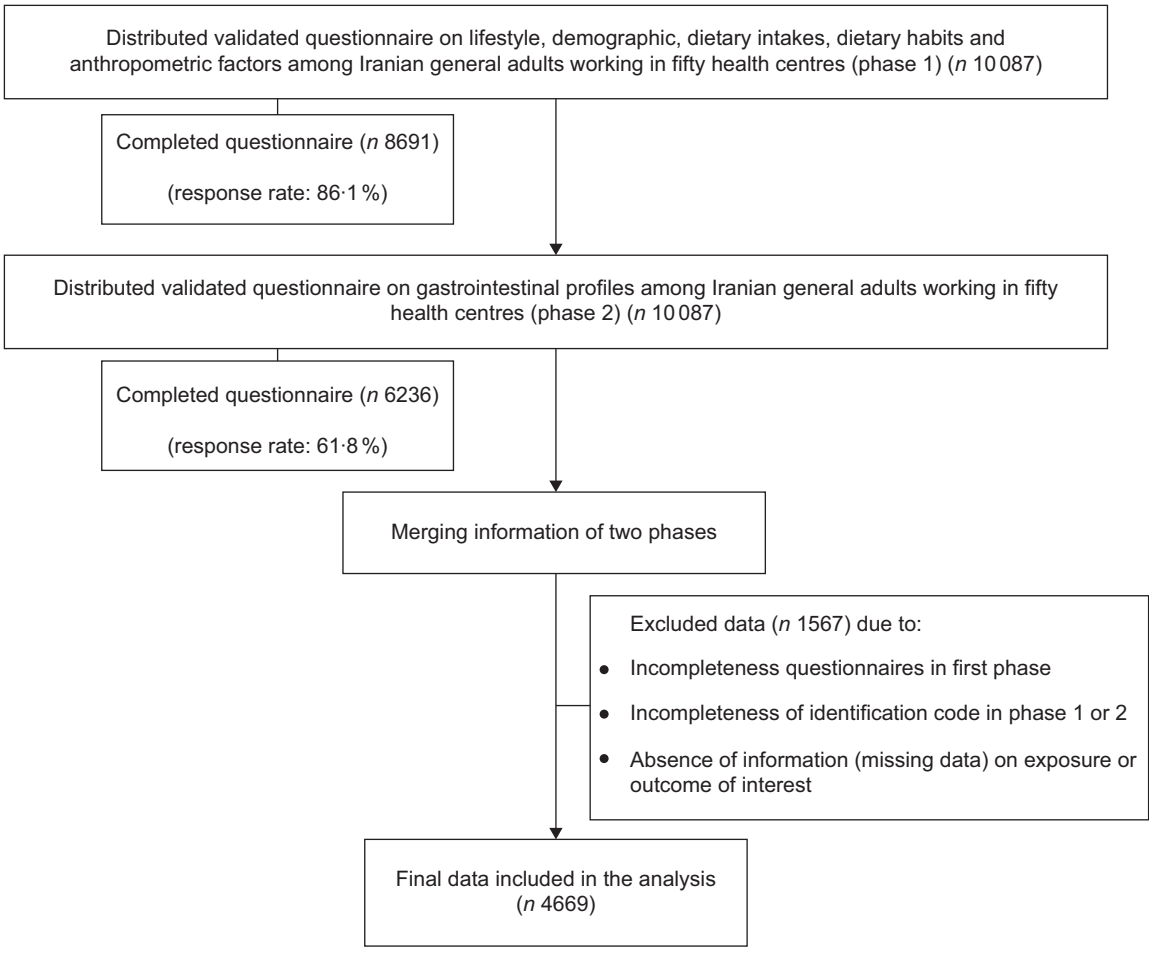

Fig. 1 Flow diagram of study population

in a pilot study on 200 participants from the same population was done and showed that self-reported values of anthropometric measures provide reasonable data of these indices. The correlation coefficient for weight, height and computed BMI from self-reported values and the one from measured values was 0·95 ($P < 0·001$), 0·83 ($P < 0·001$) and 0·70 ($P < 0·001$), respectively[22]. Participants were also asked to report the status of consuming dietary supplements (including the intake of Fe, Ca, vitamins and other dietary supplements) (yes/no), oral contraceptives pill (yes/no) and presence/absence of colitis. GI symptoms including abdominal pain, bloating, belching or diarrhoea after milk consumption were considered as lactose intolerance. Moreover, dental status was determined through a question 'how many teeth have you lost', and answer choices were the following: fully dentate, lost 1–5 teeth or more than five teeth. Data of tea, chocolate and coffee consumption were also collected through a validated 106-item FFQ[23]. With regard to tea consumption, subjects could select one of these options: never or <1 cup/month, 1–3 cups/month, 1–3 cups/week, 4–6 cups/week, 1 cup/d, 2–4 cups/d, 5–7 cups/d, 8–11 cups/d or at least 12 cups/d.

For determining physical activity levels, General Practice Physical Activity Questionnaire was utilised. Individuals with at least 1 h/week of physical activity were categorised as the active group, and the other ones were considered as the inactive ones. Meal regularity was distinguished through choosing one answer from the four-item scale (never, occasionally, often and always). For efficacy of food chewing, participants were asked to answer the question of how thoroughly do you chew food, and the possible answers were 'not very well, well or very well'. Participants were asked about the speed of their eating with this question: 'how much time do you spend eating lunch or dinner?', and the answer options were never eat lunch/dinner, <10, 10–20 and more than 20 min. Breakfast consumption information was obtained through a two-item scale (<5 and ≥5 times/week). Individuals were also asked about intra-meal fluid intake by the question of 'how often do you drink liquids before, with or after meals?', and the answers could be never,

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sometimes, often and always. The amount of beverage intake with meals was also assessed (≤1, 2–3, 3–4 and >4 glasses). Subjects have also reported the number of fried and spicy food intake per week.

Statistical analysis

One-way ANOVA and χ^2 test were used to compare continuous and categorical variables among different groups of main meal and snack frequency. In order to assess the normal distribution of variables, we used Kolmogorov–Smirnov test; all variables were normally distributed. Logistic regression in different models was used to investigate the relation between IBS symptoms and meal or snack frequency. We constructed crude and multivariable-adjusted models controlling for potential covariates. In the first model, age (continuous) and gender (categorical) were adjusted. Further adjustments in the second model were performed for physical activity (≥1 and <1 h/week), smoking status (current smoker, ex-smoker and non-smoker), marital status, education level, self-reported diabetes mellitus (yes, no), oral contraceptives pill usage (yes, no), supplement intake (yes, no), dental status, colitis (yes, no) and lactose intolerance (yes, no). Furthermore, we controlled for other variables like meal consumption regularity (regular, irregular), eating rate (<10, 10–20 and >20 min), weekly breakfast consumption (<5 and ≥5 times), intra-meal fluid intake (never or sometimes, often and always), weekly spicy food intake (never, 1–3, 4–6 and ≥7 times), fried food consumption (<4 and ≥4 times/week), quality of chewing (not well, well) and chocolate, tea and coffee consumption in the third model. BMI (kg/m^2) was also considered in the fourth model. Stratified analyses by gender and BMI status were performed, and further appropriate adjustments in subgroups were done. Individuals in the first category of main meals, snacks or both of them were assumed as the reference group. All analyses were performed with Statistical Package for Social Sciences (version 18.0; SPSS Inc.), and *P*-values <0·05 were considered as statistically significant.

Results

Mean age and weight of the study population were 36·5 (SD 8) years and 68·8 (SD 13·4) kg, respectively. A total of 2063 (44·2 %) males and 2606 (55·8 %) females aged 19–70 years were included in the analysis. Table 1 provides information about general characteristics of study participants in terms of meal or snack frequency as well as IBS status. In comparison with individuals consuming one main meal per day, participants who ate three meals per day were mostly young, and more than half of them were males and had lower percentages of smoking. They also had higher education levels and better dental status rather than aforementioned reference group. Individuals consuming more than five daily snacks were mostly younger, single, females, having higher education levels, taking more supplemental agents and having lower weight, BMI and smoking prevalence compared with participants without any snack consumption per each day. In comparison with healthy individuals, those with IBS were mostly females, had lower physical activity and had more colitis symptoms and lactose intolerance. IBS individuals had more intakes of supplement pills and more dental loss than healthy subjects. The distribution of participants based on different dietary habits across categories of meal or snack frequency and IBS is presented in Table 2. Compared with subjects eating one main meal, individuals with three daily main ones had better chewing, more regularly eating breakfasts, had more consumption of spicy and fried foods and consumed more intra-meal fluids. All eating-related habits except tea consumption were significantly different between different categories of snack frequency. IBS patients, in comparison with healthy subjects, took their lunch fast, ate their foods with less regularity, chewed the food less and had more consumption of spicy foods.

The prevalence of IBS among study subjects was 21·7 % (18·6 % in males and 24·1 % in females). The prevalence of IBS with constipation, IBS with diarrhoea, mixed IBS and un-subtyped IBS in our study was, respectively, 7·3, 4·4, 4·1 and 5·8 %. The prevalence across different categories of meal and snack consumption is shown in Fig. 2. Individuals eating three main meals every day had significantly lower prevalence of IBS compared with one or two main meals consumers ($P = 0·04$). The prevalence of other IBS subtypes was not statistically significant in terms of main meal or snack frequency or both of them.

Multivariable-adjusted OR for IBS and its subtypes across different groups of meal and snack frequency are reported in Table 3. Individuals consuming three main meals had 30 % reduced risk of IBS (OR 0·70, 95 % CI 0·52, 0·94), compared to those with one main meal, in the crude model. After adjustments for all potential confounders this relation disappeared (OR 0·67, 95 % CI 0·43, 1·03). There was no other significant relation between IBS or its subtypes and different classes of meal, snack or total main meal and snack frequency, after taking all potential confounders into account.

As depicted in Table 4, further gender-specified analysis revealed that women consuming three main meals per day had 32 % decreased likelihood of having IBS symptoms compared with one daily main meal takers (OR 0·68, 95 % CI 0·47, 0·99). This relation remained significant after adjustment for potential confounders (OR 0·56, 95 % CI 0·36, 0·89). No considerable association was found among male subjects. Dental status and presence of colitis were two confounders that made the relation statistically non-significant. Therefore, we performed stratified analysis according to the dental status among females, after excluding those with colitis (*n* 29) (see online supplementary material, Supplemental Table S1). Among women who lost

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Table 1 General characteristics of study participants across categories of meal or snack frequency as well as irritable bowel syndrome (IBS) status (*n* 4669)

	Frequency of main meals (times/d)							Frequency of snacks (times/d)								IBS status				
	1 (*n* 242)		2 (*n* 1218)		3 (*n* 3209)			0 (*n* 793)		1–2 (*n* 3195)		3–5 (*n* 623)		>5 (*n* 58)		No (*n* 3657)		Yes (*n* 1012)		
	n	%	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*P*
Age (years)							<0·001									<0·001					0·22
Mean	38·9		36·6		36·2			38·7		36·4		34·4		35·6			36·6		36·2		
SD	7·9		7·9		8·1			8·4		7·9		7·8		8·4			8·1		7·8		
Weight (kg)							0·44									<0·001					0·09
Mean	69·2		68·4		69			71·4		68·5		67·5		69·3			69		68·2		
SD	12·9		13·1		13·6			13·3		13·6		12·2		12·8			13·5		13·2		
BMI (kg/m^2)							0·20									<0·001					0·56
Mean	25·4		25·2		24·9			25·7		24·9		24·7		25			25		25·1		
SD	4·1		4·8		4·6			5·5		4·5		4·1		3·4			4·6		4·7		
Female	147	60·7	772	63·4	1687	52·6	<0·001	287	36·2	1848	57·8	433	69·7	38	65·5	<0·001	1978	54·1	628	62·1	<0·001
Married	195	80·5	969	79·5	2627	81·9	0·06	670	84·5	2614	81·8	462	74·2	45	77·5	<0·001	2948	80·6	843	83·3	0·14
Education level (≥diploma)	198	81·8	1053	86·5	2775	86·5	0·01	600	75·7	2777	86·9	594	95·4	55	94·5	<0·001	3159	86·4	867	85·7	0·84
Current smoker	61	25·2	186	15·2	440	13·7	<0·001	160	20·2	441	13·8	77	12·4	9	15·5	<0·001	536	14·6	151	14·9	0·86
Self-reported diabetes	7	2·9	23	1·9	55	1·7	0·37	20	2·5	55	1·7	8	1·3	2	3·4	0·22	66	1·8	19	1·9	0·83
Physically active*	71	29·3	435	35·7	1120	34·9	0·18	286	36	1090	34·1	228	36·6	22	37·9	0·52	1315	36	311	30·7	0·003
OCP usage	9	3·7	31	2·5	87	2·7	0·59	18	2·3	91	2·8	15	2·4	3	5·2	0·50	95	2·6	32	3·2	0·32
Supplement intake†	15	6·2	93	7·6	240	7·5	0·75	30	3·8	240	7·5	73	11·7	5	8·6	<0·001	245	6·7	103	10·2	<0·001
Colitis	5	2·1	16	1·3	36	1·1	0·33	9	1·1	43	1·3	5	0·8	0	0	0·62	30	0·8	27	2·7	<0·001
Lactose intolerance‡	41	16·9	199	16·3	458	14·3	0·16	126	15·9	473	14·8	90	14·4	9	15·5	0·86	490	13·4	208	20·6	<0·001
Dental status							<0·001									<0·001					0·01
Fully dentate	65	26·9	435	35·7	1039	32·4		198	25	1069	33·4	251	40·2	21	36·2		1244	34	295	29·2	
1–5 teeth loss	139	57·4	689	56·6	1908	59·5		487	61·4	1877	58·8	338	54·2	34	58·6		2111	57·7	625	61·7	
More than five teeth loss	38	15·7	94	7·7	262	8·1		108	13·6	249	7·8	34	5·6	3	5·2		302	8·3	92	9·1	

OCP, oral contraceptives pill.
*Physically active: ≥1 h/week.
†Supplement intake including consumption of Fe, Ca, vitamins and other dietary supplements.
‡Individuals who reported having abdominal pain, bloating, belching or diarrhoea after milk ingestion.

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Table 2 Distribution of participants in terms of diet-related behaviours across categories of meal or snack frequency as well as irritable bowel syndrome (IBS) status (*n* 4669)

	Frequency of meals (times/d)							Frequency of snacks (times/d)									IBS status				
	1 (*n* 242)		2 (*n* 1218)		3 (*n* 3209)			0 (*n* 793)		1–2 (*n* 3195)		3–5 (*n* 623)		>5 (*n* 58)			No (*n* 3657)		Yes (*n* 1012)		
	n	%	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*P*
Regular meals*	79	32·6	567	46·5	2084	64·9	<0·001	381	48·1	1906	59·7	409	65·7	34	58·6	<0·001	2172	59·4	558	55·1	<0·001
Well-chewing of foods†	185	76·6	1030	84·5	2773	86·4	<0·001	658	83	2759	86·4	525	84·3	46	79·3	0·001	3145	86	843	83·3	0·002
Rapid lunch intake†	48	19·8	187	15·4	458	14·3	<0·001	151	19	428	13·4	98	15·7	16	27·6	<0·001	524	14·3	169	16·7	0·02
Rapid dinner intake‡	53	21·9	283	23·2	716	22·3	<0·001	158	19·9	719	22·5	155	24·9	20	34·5	<0·001	798	21·8	254	25·1	0·28
Breakfast consumption (times/week)							<0·001									<0·001					0·29
<5 times/week	89	36·8	604	49·6	488	15·2		293	37	732	22·9	141	22·6	15	25·9		914	25	267	26·4	
≥5 times/week	153	63·2	614	50·4	2721	84·8		500	63	2463	77·1	482	77·4	43	74·1		2743	75	745	73·6	
Fluid intake along with meal§	13	5·4	48	3·9	141	4·4	<0·001	39	4·9	131	4·1	26	4·2	6	10·3	<0·001	154	4·2	48	4·7	0·29
Intra-meal beverage consumption‖	92	38	596	48·9	1727	53·8	<0·001	341	43	1693	53	350	56·2	31	53·4	<0·001	1885	51·5	530	52·4	0·38
Fried food intake							<0·001									<0·001					0·17
<4 times/week	164	67·8	988	81	2620	81·6		615	77·5	2633	82·4	480	77	44	75·80		2979	81·4	793	78·3	
≥4 times/week	78	32·2	230	19	589	18·4		178	22·5	562	17·6	143	23	14	24·2		678	18·6	219	21·7	
Spicy food intake (times/week)							0·001									<0·001					<0·001
Never	19	7·9	79	6·5	192	6		88	11·1	172	5·4	29	4·6	1	1·7		245	6·7	45	4·4	
1–3	102	42·1	495	40·6	1223	38·1		355	44·8	1259	39·4	191	30·7	15	25·8		1461	40	359	35·5	
4–6	80	33·1	412	33·8	1003	31·3		229	28·8	1019	31·9	228	36·6	19	32·8		1161	31·7	334	33	
≥7	41	16·9	232	19·1	791	24·6		121	15·3	745	23·3	175	28·1	23	39·7		790	21·6	274	27·1	
Tea consumption¶	166	68·6	867	71·2	2237	69·7	0·01	539	68	2262	70·8	433	69·5	36	62·1	0·24	2547	69·7	723	71·5	0·70

*Individuals who reported regular meal consumption, often or always.
†Individuals who reported chewing foods, moderately or very well.
‡Individuals who spent <10 min for meal consumption.
§Individuals who reported ≥3 glasses of beverages with meals.
‖Individuals who reported drinking fluids often or always.
¶Individuals who reported drinking tea at least two glasses daily.

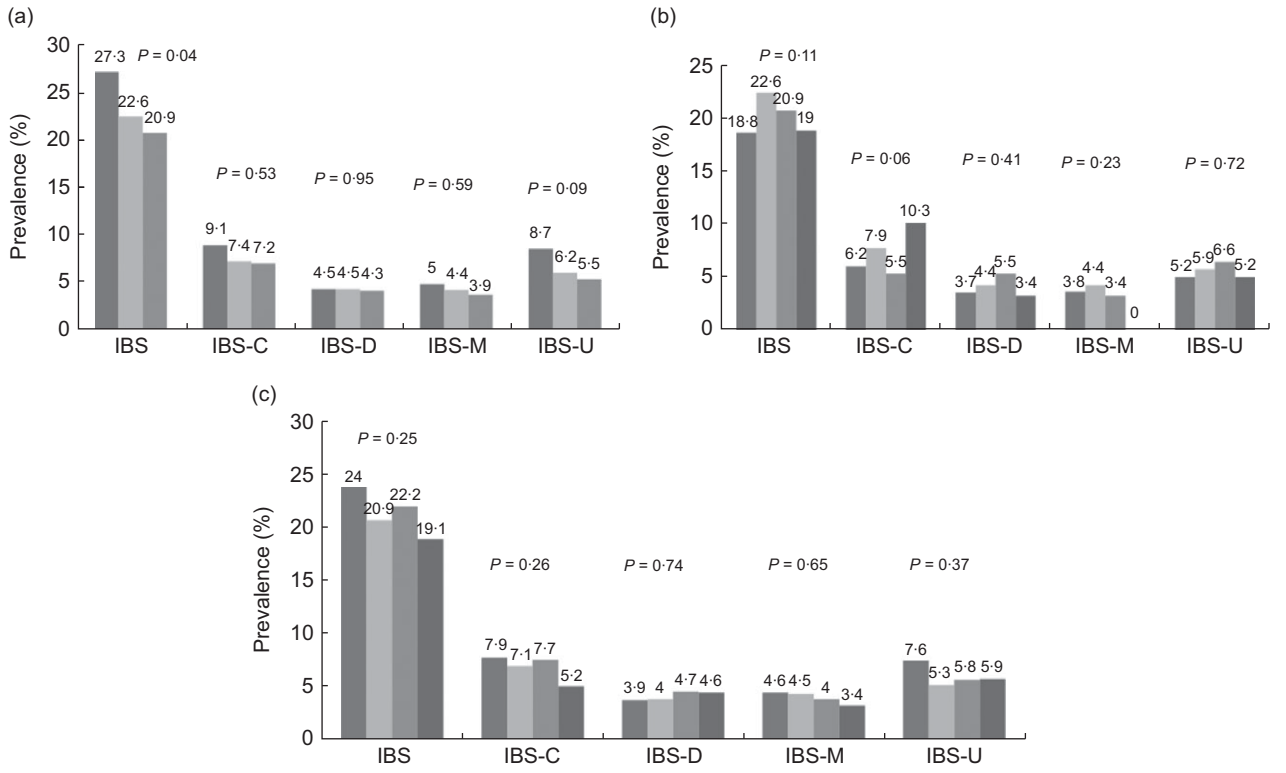

Fig. 2 Prevalence of irritable bowel syndrome (IBS) and its subtypes across categories of meal and snack frequency. (a) Main meal frequency (times/d); ■, 1; ■, 2; ■, 3. (b) Snack frequency (times/d); ■, 0; ■, 1–2; ■, 3–5; ■, >5. (c) Total meal and snacks (times/d) ; ■, <3; ■, 3–5; ■, 6–7; ■, ≥8. IBS-C, irritable bowel syndrome with constipation, IBS-D, irritable bowel syndrome with diarrhoea, IBS-M, mixed irritable bowel syndrome; IBS-U, un-subtyped irritable bowel syndrome(a) Main meal frequency (times/d); ■, 1; ■, 2; ■, 3. (b) Snack frequency (times/d); ■, 0; ■, 1–2; ■, 3–5; ■, >5. (c) Total meal and snacks (times/d) ; ■, <3; ■, 3–5; ■, 6–7; ■, ≥8. IBS-C, irritable bowel syndrome with constipation, IBS-D, irritable bowel syndrome with diarrhoea, IBS-M, mixed irritable bowel syndrome; IBS-U, un-subtyped irritable bowel syndrome

one or more teeth, those who consumed three main meals per day had 44 % decreased likelihood of IBS symptoms (OR 0·56, 95 % CI 0·32, 0·98), compared with those with one main meal per day.

Multivariable-adjusted OR for IBS prevalence across different categories of meal/snack frequency, separated by BMI status, are shown in Table 5. In obese or overweight subjects (BMI ≥ 25 kg/m^2), a 39 % (OR 0·61, 95 % CI 0·41, 0·93) decreased likelihood of IBS was found in the highest category of main meal consumption compared with the reference group (one main meal per day). After making adjustment for age and gender, this association was still significant (OR 0·63, 95 % CI 0·41, 0·97). Adjustment for other confounding variables revealed that overweight and obese individuals who consumed three main meals had 46 % (OR 0·54, 95 % CI 0·32, 0·91) decreased likelihood of IBS symptoms in comparison with those who ate one main meal. Adjustment for marital status made the relation insignificant. So, we stratified the analysis by marital status among overweight and obese individuals (see online supplementary material, Supplemental Table S2). Among married overweight and obese participants, those who consumed three main meals per day had a 43 % reduced likelihood of IBS in comparison with those taking one main meal daily (OR 0·57, 95 % CI 0·33, 0·98). When we performed stratified analysis by gender, we observed that the number of main meals was not significantly associated with IBS among married overweight and obese males or females, neither in crude nor in adjusted models (as shown in online supplementary material, Supplemental Table S3).

Discussion

We evaluated the relation of meal and snack frequency with IBS and its subtypes in a large group of Iranian adults and found that there was no significant relation between the frequency of main meals or snacks with IBS symptoms. However, a declined risk of IBS symptoms was found among female participants consuming three main meals each day based on the gender-stratified analysis. In overweight or obese participants, having more main meals was also associated with decreased odds of IBS. Moreover, we observed that among female individuals with colitis and few teeth, the number of meals was low and the prevalence of IBS was high. So, inflammation of the teeth and colon might be associated with meal frequency and IBS. It would be possible that they had fewer meals because

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Table 3 Multivariable-adjusted OR for irritable bowel syndrome (IBS) and IBS subtypes across categories of meal or/and snack frequency* (*n* 4669)

	Frequency of main meals (times/d)						Frequency of snacks (times/d)								Total number of meals and snacks (times/d)							
	1 (*n* 242)	2 (*n* 1218)		3 (*n* 3209)			0 (*n* 793)	1, 2 (*n* 3195)		3, 5 (*n* 623)		>5 (*n* 58)			<3 (*n* 433)	3, 5 (*n* 1333)		6, 7 (*n* 2426)		≥8 (*n* 477)		
	OR	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}
IBS																						
Crude	1·00	0·77	0·56, 1·06	0·70	0·52, 0·94	0·02	1·00	1·26	1·03, 1·53	1·14	0·87, 1·48	1·01	0·51, 1·99	0·37	1·00	0·83	0·64, 1·08	0·90	0·70, 1·14	0·74	0·54, 1·02	0·30
Model 1†	1·00	0·77	0·55, 1·09	0·74	0·54, 1·02	0·13	1·00	1·23	0·98, 1·53	1·10	0·82, 1·47	1·00	0·48, 2·07	0·63	1·00	0·86	0·64, 1·14	0·93	0·71, 1·21	0·76	0·54, 1·08	0·44
Model 2‡	1·00	0·73	0·50, 1·06	0·72	0·50, 1·03	0·20	1·00	1·27	1·002, 1·62	1·14	0·83, 1·57	1·07	0·49, 2·33	0·52	1·00	0·86	0·62, 1·17	0·93	0·69, 1·26	0·81	0·55, 1·18	0·67
Model 3§	1·00	0·72	0·47, 1·08	0·70	0·46, 1·07	0·21	1·00	1·22	0·94, 1·57	1·04	0·75, 1·46	0·86	0·39, 1·90	0·91	1·00	0·87	0·61, 1·23	0·92	0·65, 1·31	0·77	0·50, 1·18	0·42
Model 4‖	1·00	0·65	0·43, 1·00	0·67	0·43, 1·03	0·23	1·00	1·17	0·90, 1·53	1·01	0·72, 1·42	0·87	0·39, 1·94	0·81	1·00	0·83	0·58, 1·18	0·89	0·62, 1·27	0·74	0·48, 1·15	0·40
IBS-C																						
Crude	1·00	0·79	0·49, 1·30	0·77	0·48, 1·22	0·36	1·00	1·30	0·95, 1·79	0·87	0·55, 1·37	1·75	0·71, 4·28	0·92	1·00	0·90	0·59, 1·35	0·98	0·67, 1·44	0·64	0·38, 1·10	0·39
Model 1†	1·00	0·69	0·40, 1·16	0·84	0·51, 1·36	0·68	1·00	1·24	0·86, 1·78	0·78	0·47, 1·28	1·50	0·56, 4·04	0·51	1·00	1·03	0·64, 1·64	1·15	0·74, 1·78	0·73	0·40, 1·31	0·70
Model 2‡	1·00	0·70	0·39, 1·26	0·81	0·47, 1·40	0·89	1·00	1·35	0·90, 2·02	0·85	0·49, 1·46	1·57	0·51, 4·82	0·69	1·00	0·93	0·56, 1·55	1·09	0·68, 1·75	0·70	0·37, 1·32	0·74
Model 3§	1·00	0·56	0·30, 1·06	0·76	0·40, 1·44	0·73	1·00	1·32	0·85, 2·04	0·75	0·42, 1·34	1·31	0·41, 4·13	0·34	1·00	0·85	0·49, 1·49	1·04	0·59, 1·82	0·61	0·30, 1·25	0·52
Model 4‖	1·00	0·53	0·28, 1·01	0·72	0·37, 1·39	0·80	1·00	1·34	0·86, 2·10	0·79	0·44, 1·42	1·40	0·44, 4·46	0·43	1·00	0·87	0·49, 1·55	1·06	0·60, 1·89	0·64	0·31, 1·33	0·58
IBS-D																						
Crude	1·00	0·99	0·51, 1·92	0·95	0·50, 1·78	0·77	1·00	1·20	0·80, 1·81	1·52	0·91, 2·52	0·94	0·21, 4·04	0·17	1·00	1·01	0·58, 1·76	1·19	0·71, 2·01	1·18	0·62, 2·25	0·33
Model 1†	1·00	1·19	0·55, 2·55	1·10	0·53, 2·29	0·90	1·00	1·32	0·83, 2·11	1·80	1·02, 3·19	1·20	0·27, 5·28	0·06	1·00	1·004	0·53, 1·89	1·27	0·70, 2·30	1·34	0·66, 2·74	0·16
Model 2‡	1·00	1·02	0·47, 2·24	0·98	0·46, 2·08	0·86	1·00	1·27	0·78, 2·07	1·65	0·91, 3·01	1·09	0·24, 4·93	0·14	1·00	0·92	0·48, 1·75	1·12	0·61, 2·06	1·25	0·60, 2·60	0·27
Model 3§	1·00	1·13	0·49, 2·59	0·91	0·39, 2·12	0·44	1·00	1·19	0·71, 1·96	1·61	0·87, 2·99	0·91	0·19, 4·20	0·21	1·00	0·88	0·44, 1·76	1·06	0·53, 2·11	1·19	0·53, 2·68	0·45
Model 4‖	1·00	1·06	0·46, 2·44	0·81	0·35, 1·89	0·28	1·00	1·12	0·67, 1·88	1·57	0·83, 2·95	0·92	0·19, 4·33	0·23	1·00	0·84	0·42, 1·68	0·97	0·48, 1·94	1·10	0·48, 2·50	0·60
IBS-M																						
Crude	1·00	0·88	0·46, 1·68	0·78	0·42, 1·43	0·30	1·00	1·17	0·78, 1·75	0·88	0·50, 1·56	–		0·40	1·00	0·97	0·58, 1·63	0·85	0·52, 1·39	0·71	0·36, 1·40	0·21
Model 1†	1·00	0·95	0·47, 1·91	0·81	0·42, 1·59	0·34	1·00	1·29	0·82, 2·01	1·04	0·56, 1·92	–		0·73	1·00	1·02	0·57, 1·81	0·90	0·52, 1·56	0·79	0·38, 1·63	0·37
Model 2‡	1·00	0·86	0·38, 1·94	0·86	0·40, 1·85	0·81	1·00	1·52	0·91, 2·55	1·17	0·58, 2·37	–		0·99	1·00	1·31	0·66, 2·62	1·12	0·57, 2·20	1·15	0·50, 2·65	0·87
Model 3§	1·00	0·78	0·33, 1·85	0·73	0·30, 1·74	0·44	1·00	1·30	0·76, 2·23	1·006	0·47, 2·11	–		0·59	1·00	1·19	0·57, 2·47	0·86	0·40, 1·83	0·96	0·38, 2·42	0·39
Model 4‖	1·00	0·72	0·30, 1·74	0·78	0·32, 1·90	0·72	1·00	1·15	0·67, 1·99	0·88	0·41, 1·88	–		0·39	1·00	1·09	0·52, 2·31	0·86	0·40, 1·85	0·88	0·34, 2·27	0·41
IBS-U																						
Crude	1·00	0·70	0·42, 1·16	0·61	0·38, 0·98	0·04	1·00	1·14	0·81, 1·62	1·29	0·82, 2·01	1·00	0·30, 3·33	0·33	1·00	0·68	0·44, 1·04	0·74	0·50, 1·10	0·75	0·44, 1·27	0·51
Model 1†	1·00	0·71	0·41, 1·21	0·59	0·35, 0·98	0·03	1·00	0·99	0·68, 1·44	1·07	0·66, 1·74	0·98	0·29, 3·30	0·80	1·00	0·64	0·40, 1·006	0·65	0·42, 0·99	0·63	0·36, 1·11	0·17
Model 2‡	1·00	0·69	0·38, 1·24	0·58	0·33, 1·02	0·05	1·00	0·91	0·61, 1·36	1·05	0·63, 1·76	1·03	0·29, 3·58	0·80	1·00	0·64	0·39, 1·06	0·66	0·41, 1·05	0·64	0·35, 1·18	0·24
Model 3§	1·00	0·77	0·39, 1·53	0·68	0·33, 1·36	0·28	1·00	0·94	0·61, 1·44	1·05	0·61, 1·81	0·98	0·27, 3·50	0·79	1·00	0·81	0·46, 1·42	0·83	0·46, 1·47	0·76	0·37, 1·56	0·64
Model 4‖	1·00	0·73	0·37, 1·45	0·67	0·33, 1·35	0·33	1·00	0·92	0·60, 1·42	1·003	0·57, 1·74	1·007	0·28, 3·59	0·89	1·00	0·77	0·43, 1·36	0·78	0·44, 1·40	0·75	0·36, 1·54	0·62

*IBS was assessed as having abdominal discomfort or pain at least sometimes in the last 3 months prior to the initiation of study with association of at least two of the followings: improvement with defaecation and changing in stool form or frequency.
†Model 1: adjusted for age and gender.
‡Model 2: adjusted for age, gender, physical activity, smoking, marital status, education level, self-reported diabetes, oral contraceptives pill usage, supplement intake, dental status, colitis and lactose intolerance.
§Model 3: further adjusted for meal regularity (non-regular, regular), eating rate (non-quick, quick or <10 min), breakfast consumption, intra-meal fluid intake (never or sometimes, often or always), spicy food intake (never, 1–3, 4–6 or ≥7 times/week), fried food intake (ordinal), frequency of fluid intake (ordinal), chewing efficiency (not well, well), chocolate consumption, tea consumption and coffee consumption.
‖Model 4: further adjusted for BMI.

Table 4 Multivariable-adjusted OR for irritable bowel syndrome (IBS) across categories of meal f or/and snack frequency separated by gender* (*n* 4669)

	Frequency of main meals (time/d)						Frequency of snacks (times/d)								Total number of meals and snack (times/d)							
	1 (*n* 242)	2 (*n* 1218)		3 (*n* 3209)			0 (*n* 793)	1–2 (*n* 3195)		3–5 (*n* 623)		>5 (*n* 58)			<3 (*n* 433)	3–5 (*n* 1333)		6–7 (*n* 2426)		≥8 (*n* 477)		
	OR	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}
Men																						
Crude	1·00	0·81	0·47, 1·40	0·79	0·47, 1·30	0·43	1·00	1·26	0·96, 1·66	1·17	0·75, 1·81	0·57	0·13, 2·52	0·41	1·00	0·74	0·50, 1·11	0·96	0·66, 1·39	0·77	0·45, 1·32	0·76
Model 1†	1·00	0·82	0·43, 1·57	0·90	0·49, 1·65	0·85	1·00	1·42	1·03, 1·94	1·40	0·86, 2·27	0·65	0·14, 2·91	0·32	1·00	0·78	0·48, 1·27	1·12	0·71, 1·76	0·99	0·54, 1·83	0·15
Model 2‡	1·00	0·77	0·40, 1·49	0·88	0·47, 1·62	0·78	1·00	1·45	1·05, 2·00	1·44	0·88, 2·34	0·69	0·15, 3·07	0·14	1·00	0·79	0·48, 1·30	1·15	0·72, 1·83	1·02	0·55, 1·91	0·12
Model 3§	1·00	0·76	0·37, 1·54	0·86	0·45, 1·66	0·84	1·00	1·38	0·98, 1·93	1·38	0·82, 2·32	0·57	0·12, 2·66	0·29	1·00	0·80	0·47, 1·36	1·07	0·65, 1·77	1·06	0·55, 2·06	0·22
Model 4‖	1·00	0·76	0·37, 1·59	0·89	0·45, 1·76	0·73	1·00	1·42	0·99, 2·03	1·41	0·83, 2·42	0·47	0·09, 2·32	0·32	1·00	0·86	0·49, 1·49	1·15	0·68, 1·96	1·14	0·57, 2·26	0·18
Model 5¶	1·00	0·70	0·33, 1·46	0·77	0·39, 1·55	0·93	1·00	1·32	0·92, 1·90	1·32	0·76, 2·30	0·46	0·09, 2·28	0·49	1·00	0·79	0·45, 1·39	1·02	0·60, 1·74	0·98	0·48, 1·98	0·42
Women																						
Crude	1·00	0·74	0·50, 1·09	0·68	0·47, 0·99	0·06	1·00	1·08	0·80, 1·44	0·92	0·64, 1·31	1·01	0·46, 2·26	0·53	1·00	0·91	0·64, 1·27	0·84	0·61, 1·16	0·68	0·45, 1·02	0·05
Model 1	1·00	0·75	0·50, 1·12	0·68	0·46, 1·00	0·05	1·00	1·06	0·78, 1·44	0·92	0·63, 1·34	1·06	0·45, 2·48	0·55	1·00	0·91	0·64, 1·30	0·83	0·60, 1·16	0·68	0·45, 1·04	0·05
Model 2	1·00	0·80	0·53, 1·20	0·72	0·49, 1·06	0·08	1·00	1·08	0·79, 1·49	0·94	0·64, 1·37	1·15	0·49, 2·72	0·68	1·00	0·93	0·65, 1·33	0·86	0·61, 1·21	0·70	0·46, 1·08	0·08
Model 3	1·00	0·72	0·46, 1·13	0·66	0·43, 1·01	0·07	1·00	1·15	0·81, 1·64	1·00	0·66, 1·53	1·21	0·48, 3·09	0·88	1·00	0·89	0·60, 1·32	0·85	0·58, 1·23	0·70	0·44, 1·11	0·13
Model 4	1·00	0·66	0·41, 1·06	0·60	0·38, 0·95	0·05	1·00	1·09	0·76, 1·57	0·96	0·62, 1·48	1·16	0·45, 3·02	0·77	1·00	0·83	0·55, 1·25	0·78	0·52, 1·15	0·65	0·40, 1·05	0·08
Model 5	1·00	0·59	0·37, 0·95	0·56	0·36, 0·89	0·06	1·00	1·11	0·77, 1·61	0·98	0·63, 1·52	1·27	0·48, 3·35	0·85	1·00	0·78	0·51, 1·18	0·75	0·51, 1·12	0·64	0·39, 1·05	0·11

*IBS was assessed as having abdominal discomfort or pain at least sometimes in the last 3 months prior to the initiation of study with association of at least two of the followings: improvement with defaecation and changing in stool form or frequency.
†Model 1: adjusted for age.
‡Model 2: adjusted for age, dental status and colitis.
§Model 3: adjusted for age, physical activity, smoking, marital status, education level, self-reported diabetes, oral contraceptives pill usage, supplement intake, dental status, colitis and lactose intolerance.
‖Model 4: further adjusted for meal regularity (non-regular, regular), eating rate (non-quick, quick or <10 min), breakfast consumption, intra-meal fluid intake (never or sometimes, often or always), spicy food intake (never, 1–3, 4–6 or ≥7 times/week), fried food intake (ordinal), frequency of fluid intake (ordinal), chewing efficiency (not well, well), chocolate consumption, tea consumption and coffee consumption.
¶Model 5: further adjusted for BMI.

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Table 5 Multivariable-adjusted OR for irritable bowel syndrome (IBS) across categories of meal or/and snack frequency separated by BMI status* (*n* 4669)

	Frequency of main meals (times/d)						Frequency of snacks/ (times/d)								Total number of meals and snack (times/d)							
	1 (*n* 242)	2 (*n* 1218)		3 (*n* 3209)			0 (*n* 793)	1–2 (*n* 3195)		3–5 (*n* 623)		>5 (*n* 58)			<3 (*n* 433)	3–5 (*n* 1333)		6–7 (*n* 2426)		≥8 (*n* 477)		
	OR	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	P_{trend}
BMI < 25 (kg/m^2)																						
Crude	1·00	0·77	0·48, 1·23	0·74	0·47, 1·15	0·26	1·00	1·044	0·78, 1·38	0·92	0·64, 1·33	1·24	0·51, 3·04	0·84	1·00	0·83	0·56, 1·21	0·83	0·58, 1·18	0·75	0·48, 1·17	0·30
Model 1†	1·00	0·81	0·48, 1·35	0·80	0·49, 1·31	0·55	1·00	1·02	0·74, 1·41	0·91	0·61, 1·38	1·50	0·59, 3·80	0·94	1·00	0·85	0·55, 1·30	0·87	0·59, 1·30	0·78	0·48, 1·28	0·50
Model 2‡	1·00	0·76	0·46, 1·28	0·75	0·46, 1·23	0·42	1·00	0·98	0·71, 1·35	0·88	0·58, 1·33	1·64	0·64, 4·24	0·88	1·00	0·80	0·52, 1·23	0·81	0·54, 1·21	0·75	0·46, 1·23	0·38
Model 3§	1·00	0·68	0·38, 1·19	0·71	0·41, 1·21	0·57	1·00	1·09	0·76, 1·00	0·90	0·57, 1·43	1·68	0·60, 4·74	0·88	1·00	0·74	0·46, 1·18	0·81	0·52, 1·26	0·71	0·42, 1·22	0·54
Model 4‖	1·00	0·63	0·35, 1·13	0·70	0·40, 1·23	0·79	1·00	1·10	0·76, 1·60	0·94	0·59, 1·51	1·68	0·57, 4·90	0·99	1·00	0·72	0·44, 1·16	0·83	0·53, 1·32	0·75	0·43, 1·30	0·80
BMI ≥ 25 (kg/m^2)																						
Crude	1·00	0·70	0·45, 1·09	0·61	0·41, 0·93	0·02	1·00	1·42	1·06, 1·90	1·36	0·92, 2·01	0·75	0·25, 2·24	0·22	1·00	0·79	0·54, 1·14	0·90	0·64, 1·28	0·68	0·42, 1·11	0·51
Model 1	1·00	0·66	0·41, 1·05	0·63	0·41, 0·97	0·10	1·00	1·36	0·99, 1·87	1·24	0·81, 1·90	0·57	0·16, 1·99	0·59	1·00	0·78	0·52, 1·15	0·90	0·62, 1·31	0·67	0·40, 1·12	0·51
Model 2	1·00	0·70	0·43, 1·13	0·66	0·42, 1·04	0·13	1·00	1·33	0·97, 1·83	1·25	0·82, 1·92	0·56	0·16, 1·95	0·61	1·00	0·80	0·54, 1·21	0·92	0·63, 1·35	0·70	0·42, 1·17	0·58
Model 3	1·00	0·65	0·38, 1·09	0·60	0·37, 0·99	0·09	1·00	1·34	0·95, 1·89	1·32	0·83, 2·10	0·60	0·17, 2·13	0·52	1·00	0·85	0·55, 1·31	0·91	0·59, 1·38	0·77	0·44, 1·34	0·58
Model 4	1·00	0·58	0·34, 1·02	0·54	0·32, 0·91	0·06	1·00	1·30	0·91, 1·85	1·22	0·75, 1·97	0·55	0·15, 1·99	0·80	1·00	0·84	0·53, 1·34	0·84	0·53, 1·31	0·73	0·40, 1·28	0·33

*IBS was assessed as having abdominal discomfort or pain at least sometimes in the last 3 months prior to the initiation of study with association of at least two of the followings: improvement with defaecation and changing in stool form or frequency.
†Model 1: adjusted for age and gender.
‡Model 2: adjusted for age, gender and marital status.
§Model 3: adjusted for age, gender, physical activity, smoking, marital status, education level, self-reported diabetes, oral contraceptives pill usage, supplement intake, dental status, colitis and lactose intolerance.
‖Model 4: further adjusted for meal regularity (non-regular, regular), eating rate (non-quick, quick or <10 min), breakfast consumption, intra-meal fluid intake (never or sometimes, often or always), spicy food intake (never, 1–3, 4–6 or ≥7 times/week), fried food intake (ordinal), frequency of fluid intake (ordinal), chewing efficiency (not well, well), chocolate consumption, tea consumption and coffee consumption.

they had fewer teeth or because of colitis symptoms; this point should be considered while interpreting our findings. We used Rome III diagnostic criteria in order to estimate the prevalence of IBS as 21·7 %. However, it must be taken into account that this prevalence could be considerably lower in terms of recently released Rome IV criteria for IBS definition. Since IBS is one of the most common GI disorders with high prevalence and considerable economic burden[3,11], it might be advisable for populations to have more meals in order to decrease the prevalence of IBS symptoms, especially in female individuals. Findings of several previous investigations were consistent with the current study[5,24,25]. For instance, in a cross-sectional study among 1717 Korean students, Kim & Ban[24] reported that individuals suffering from IBS missed their daily meals more frequently compared with healthy subjects. Also, skipping meals was significantly more prevalent in IBS middle-aged patients rather than normal individuals in another cross-sectional investigation[5]. Okami *et al.*[25] reported the same finding from nursing and medical school students in Japan. In contrast, several studies failed to prove any significant association[16,17,20]. In a cross-sectional study among 193 urban Romanian adults, meal or snack frequency was not associated with IBS. However, the small number of sample size and not considering all potential confounders might influence this finding[16]. Khayyatzadeh *et al.*[17] have studied 988 Iranian adolescent girls aged 12–18 years and found that neither main meals nor snack frequency was a significant association with IBS symptoms in crude or adjusted models. Moreover, in a cross-sectional study among 245 Japanese females aged 18–32 years, skipping meals had no significant association with IBS. Again, small sample size should be taken into account while interpreting this finding[20].

The observed gender disparity in the associations in the current study might be related to higher prevalence of IBS among women. Another reason might be the difference in accuracy of reporting dietary habits among females and males; women might report dietary behaviours more accurately than men.

The exact pathophysiological mechanisms explaining inverse relations between meal or snack frequency and IBS symptoms have yet to be explored. One possible theory would be related to GI motility. It has been suggested that skipping meal consumption was associated with the loss of gastro-colonic reflex and impacted faeces[26]. By increasing frequency of main meal taking, this reflex might be improved and would lead to decreased symptoms of IBS. Further prospective studies are necessary to prove a causal relation.

Investigating a large sample size of adults and considering several potential confounders were the strengths of our study. Also, we recruited participants from different job categories and excluded faculty members of teaching hospitals or research institutes to decrease probable conflict of interests. However, the current investigation had some limitations. Cross-sectional design of the study was the most important limitation which prevented us to have a causal relationship. Furthermore, the possibility of reverse causality should be considered in such kind of studies in a way that individuals with IBS might reduce the frequency of their meals or snacks in order to attenuate the symptoms. Recall bias is an inevitable disadvantage in any researches which recall of events is required. We tried our best to consider all potential confounders, but some other factors might negatively affect our findings. Almost all Iranians are muslims and have religious prohibitions that preclude the use of alcohol. Therefore, alcohol consumption, an important covariate for IBS, in our study population was very low, and data in this regard were not collected in the current study. Since this investigation was conducted among Iranian population, generalisation of results to other nations must be cautiously done.

In conclusion, our findings suggested that although there was no significant association between the numbers of main meals and snacks with IBS symptoms, a small inverse relation was found in terms of main meal and IBS in females and overweight or obese individuals. Further prospective studies are needed to confirm these associations.

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Supplementary material

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