BMC Public Health

RESEARCH

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Adherence to global diet quality score in relation to gastroesophageal reflux disease and flatulence in Iranian adults

Fatemeh Sadat Mirjalili[1,2], Mina Darand[3], Saeed Fallah-Aliabadi[4], Hassan Mozaffari-Khosravi[2] and Sayyed Saeid Khayyatzadeh[1,2,5*]

Abstract

Introduction Gastroesophageal reflux disease (GERD) and flatulence are both prevalent afflictions and negatively impact the quality of life. This study aims to determine the relationship between the Global Diet Quality Score (GDQS), a novel metric based on the Prime Diet Quality Score with GERD and flatulence in Iranian adults.

Methods The cross-sectional study was conducted among 6202 adults in the context of the Shahedieh cohort study accomplished. Dietary intakes of participants were collected by food frequency questionnaires (FFQs). To calculate GDQS, 25 food groups were comprised (16 healthy and 7 unhealthy food groups and two food groups categorized as unhealthy when consumed excessively). GERD and flatulence were assessed by a self-reported questionnaire. To examine the association between GDQS with GERD and flatulence, logistic regression was performed in crude and adjusted models (Model I: adjustments for age and energy intake; Model II: gender, physical activity, marital status, occupation, educational levels, WSI, and BMI; and Model III: smoking status, depression, diabetes, hypertension, and cardio events.)

Results Participants in the highest quintile of GDQS had 20% higher odds of having GERD than individuals in the lowest one (OR: 1.20; 95% CI: 0.88–1.65, P trend = 0.508). Compared to the lowest quintile, the participants in the highest quintile had no significant reduction in probability of having flatulence in the crude model (OR: 0.94; 95% CI: 0.81–1.11, P trend = 0.578). These associations remained non-significant after adjustments for confounding variables.

Conclusion No significant associations were observed between higher adherence to GDQS with odds of GERD and flatulence in Iranian adults. To better understand these findings, longitudinal studies especially randomized clinical trials are needed.

Keywords Gastroesophageal reflux disease (GERD), Flatulence, Global Diet Quality Score (GDQS), Dietary patterns

*Correspondence:
Sayyed Saeid Khayyatzadeh
khayyatzadeh@yahoo.com
Full list of author information is available at the end of the article

Introduction

Gastrointestinal diseases are widespread worldwide, leading to considerable distress and destruction and affecting individuals' quality of life. Notably, gastrointestinal disorders significantly contribute to health care utilization and cost [1]. Functional gastrointestinal disorders (FGID), often known as gut-brain interaction disorders, consist of persistent abdominal symptoms without any detectable structural cause [2], and gastroesophageal reflux disease (GERD), a condition occurs when the reflux of stomach contents causes troublesome symptoms [3], are prevalent gastrointestinal ailments and negatively impact the quality of life [4, 5]. GERD symptoms, typically heartburn and regurgitation [3], are common in 43.07% of Iranian people [6]. Furthermore, Flatulence is a common compliment among patients with FGID, who ascribed their symptoms to lots of intestinal gas [7]. More than 40% of people globally have FGIDs associated with more frequent doctor visits and are characterized by chronic or recurrent abdominal symptoms of pain [4]. Lower educational level or income, advancing age, and nonsteroidal anti-inflammatory drug)NSAID(use are some risk factors for GERD symptoms [8]. Moreover, GERD is related to diverse behavioral factors, including body weight (obesity), tobacco smoking, sleeping position, and eating habits, such as eating very hot foods, fast eating, and eating beyond [9]. In addition to dietary habits, the nutritional composition of the diet plays a crucial role. The severity and occurrence of symptoms in individuals with specific digestive disorders are mainly influenced by different dietary factors such as fat and fiber [10, 11]. Moreover, fermentable substrates reaching the colon and the individual's microbiota composition can affect the amount of gas produced [12]. Previous studies indicate GERD is directly associated with consumption fried, fatty, spicy, sour food/products, citruses, tomatoes, coffee/tea, chocolate, and carbonated beverages [13]. While, recent studies demonstrates that adherence to a low FODMAP diet leads to the overall improvement of FGID and GERD symptoms [14, 15]. However, most studies on diet and GERD or FGID have centered mainly on single food items, rather than dietary patterns.

Defining the overall diet score may be more critical in reducing GERD and Flatulence as a sign of FGID. The Global Diet Quality Score (GDQS) based on the Prime Diet Quality Score was developed by Bromage et al. to monitor diet quality. This novel metric comprises 25 food groups (16 healthy, seven unhealthy, and two unhealthy groups categorized as unhealthy when consumed excessively, including high-fat dairy and red meat) [16]. Higher GDQS scores are associated with higher adherence to a healthy dietary pattern characterized by high amounts of deep orange tubers, deep orange vegetables, fruits, and whole grains, which are sources of fiber. The high dietary fiber content in the GDQS might play an essential role in the probability of having GERD [17].

To our knowledge, no study has investigated the association between GDQS and GERD and flatulence. Accordingly, the present cross-sectional study, which analyzes data from a subset of the PERSIAN cohort study, aims to determine the relationship between GDQS and symptoms of GERD and flatulence in a defined population. By addressing this research gap, the study could provide valuable insights into how dietary quality, as measured through the GDQS, can influence the management of gastrointestinal disorders like GERD and flatulence, with potential implications for public health interventions.

Methods

Study population

This study is a cross-sectional analysis of data from a subset of the more extensive PERSIAN cohort study [18] conducted across various regions in Iran. Shahedieh cohort study recruited 9971 adults with ages 35 to 70 and residing in municipal areas of Yazd city (Zarch and Shahedieh) from 2016, for at least nine months annually. Participants with a history of cancer, renal failure, and multiple sclerosis, as well as pregnant individuals and those under or over-reported energy intake (below 800 kcal; above 4500 kcal), were excluded. The final analysis was conducted on 6202 individuals (Fig. 1 shows how many participants were removed at each stage). This study was performed per the guidelines in the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee (IR.SSU.SPH.REC.1400.211) of Shahid Sadoughi University of Medical Sciences, Yazd, Iran. Informed consent was obtained from all participants before their enrollment in the study, and their participation was voluntary.

Dietary assessment

A semi-quantitative food frequency questionnaire (FFQ) was employed to evaluate dietary foods, comprising 120 items [19]. Trained interviewers administered this validated FFQ to the Iranian population, where participants reported the monthly, weekly, or daily amount and frequency of consuming each food item over the past year; participants reported their intake frequency on a 10-choice scale, ranging from 'never or less than once a month' to '10 or more times per day. All reported intakes were converted to g/day using household portion sizes of consumed foods. The USDA food database was used to calculate nutrient intakes [20].

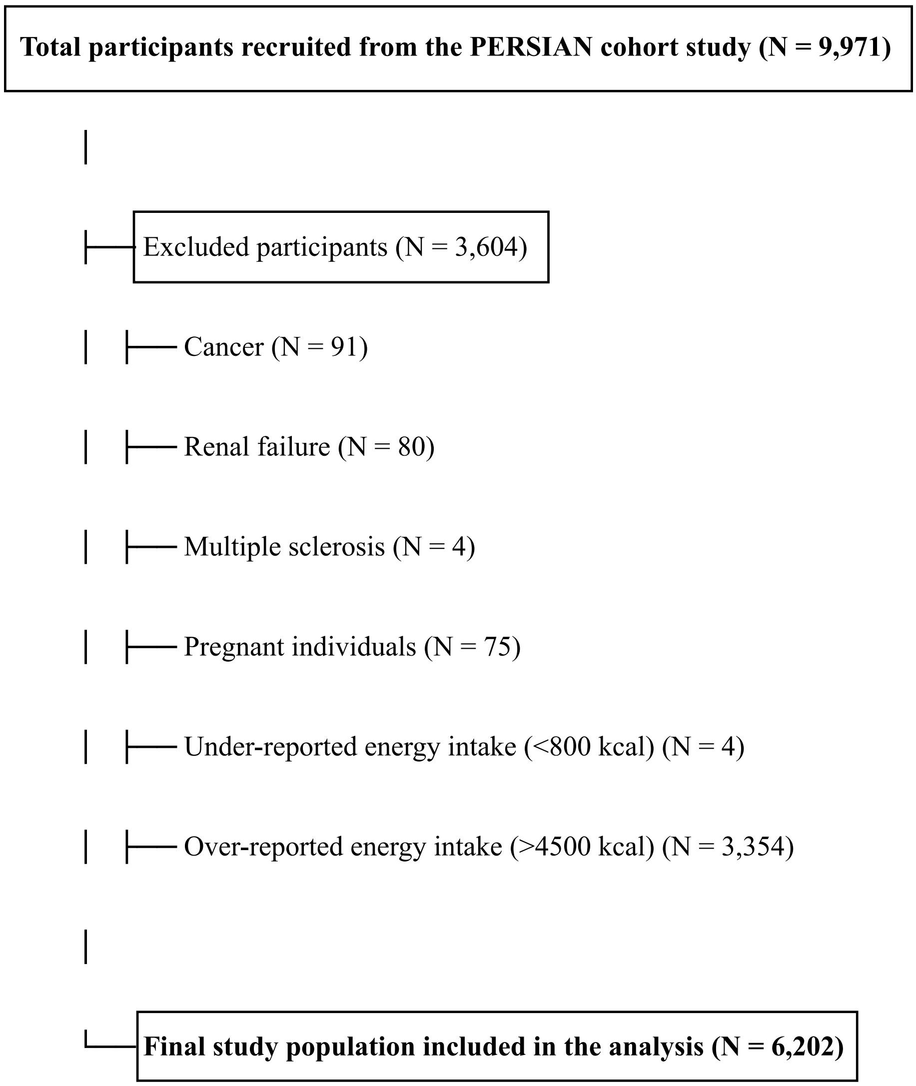

Fig. 1 Flowchart of participant selection and exclusion criteria

The calculation of GDQS scores

The GDQS comprises 25 food groups, each assigned points based on consumed amounts categorized into three or four groups (measured in g/d) particular to each group. Table 2 outlines the scoring for these food groups, including 16 healthy groups where higher intake earns more points, seven unhealthy groups (Processed meat, Refined grains, Sweets and ice cream, Sugar-sweetened beverages, Juice, White roots and tubers, purchased deep fried foods) scoring higher for lower intake, and two groups (High-fat dairy and red meat) considered unhealthy in excess (more points for lower intake). The GDQS is calculated by summing points across all 25 food groups, resulting in a score ranging from 0 to 49 [16]. For a comprehensive explanation of the scoring methodology for each food group, please see Supplementary Table 1.

GERD and flatulence assessments

History of GERD and flatulence symptoms was assessed using a self-reported questionnaire in a subset of the medical history section of the Shahedieh cohort study, which covered the participants' medical history over the past year [18]. GERD was defined as having heartburn and/or regurgitation symptoms occurring at least several times a month, and participants were asked whether they had been diagnosed with GERD by a physician. Additionally, flatulence and bloating were assessed with the question: 'Have you experienced bloating and distension of the abdomen, especially after eating, during the past year?

Anthropometric measurement

Weight was determined using digital scales. Individuals wore minimal clothing and did not wear shoes, and measurements were noted to the nearest 100 g. Height was measured using a wall-fixed tape measure smoothly, with a precision of 0.5 cm. The body mass index (BMI) was computed by dividing weight (kg) by height (meters) squared.

Physical activity measurement

Participants were queried about their regular physical activity during the preceding year and whether they held seasonal employment. Data obtained from the questionnaire were translated into metabolic equivalent of task hours per week (MET-h/wk). Subsequently, these MET-h/wk values were classified into sedentary, moderate, and active categories, with the classification determined by the median of MET-h/wk levels.

Measurement of other variables

Information on various variables, including age, gender, marital status (single, married, widowed, or divorced), body mass index (BMI), smoking (never, current and ex-smoker), and education (illiterate, diploma and subdiploma education, university education), was collected through questionnaires. Additionally, Socioeconomic status (SES) was evaluated using the Wealth Status Index (WSI) developed for the PERSIAN cohort study. This index was derived through multiple correspondence analysis (MCA) based on assets, device ownership, and other socioeconomic indicators, allowing for the classification of wealth quintiles [21]. Health conditions, including depression, diabetes, hypertension, and cardiac events (such as myocardial infarction, stroke, and ischemia) as cofounders, were assessed as confounders using a medical history questionnaire.

Statistical analyses

We expressed general characteristics and dietary intakes across GDQS score quantile as means ± SD and numbers (percentage) for continuous and categorical variables, respectively. Continuous and categorical variables across GDQS score quantile were assessed using one-way ANOVA and chi-square tests. Binary logistic regression examined the association between GQDS adherence and GERD/Flatulence in crude and multivariable-adjusted models. Model I adjusted for age and energy intake, while Model II included gender, physical activity, marital status, occupation, educational levels, WSI, and BMI. Furthermore, model III adjusted for smoking status, depression, diabetes, hypertension, cardio events (MI, stroke, ischemic). Statistical analyses used SPSS (version 27, IBM Corporation, USA), with p-values < 0.05 considered statistically significant.

Results

General characteristics variables of the participants, stratified by quintiles of GDQS, are represented in Table 1. There was a significant difference between age, gender, BMI, educational level, wealth score index, marital and occupation status, and the presence of depression, hypertension, and cardiac events (MI, stroke, and ischemic) among GDQS quantiles. Furthermore, no remarkable difference was observed among the smoking status, metabolic equivalent of task presence of GERD, flatulence, and Diabetes, and quintiles of GDQS.

The energy and dietary intakes of study participants by quantiles of GDQS are displayed in Table 2 (Food groups) and Table 3 (Nutrients). Food groups of GDQS metric are reported Table 2 (g/1000 kcal). In Table 2, energy-adjusted intakes of citrus fruits, deep orange fruits (gr/1000 kcal), other fruits, dark green leafy vegetables, cruciferous vegetables, other vegetables, legumes, deep orange tubers, nuts and seeds, whole grains, liquid oils, fish and shellfish, poultry and game meat, eggs, high-fat dairy, refined grains and baked goods, sweets and ice cream, sugar-sweetened beverages, white roots and tubers were significantly different among the quintiles of GDQS. No remarkable differences were observed between red meat, processed meat, juice, and purchased deep-fried foods among quantiles of GDQS.

Furthermore, Table 3 focuses on nutrient intakes. Energy intake, dietary fiber intake and intakes of other macronutrients based on total daily energy are significantly different among the quantiles of GDQS. Differences in energy-adjusted intake of micronutrients according to quantiles of GDQS were significant except for folate.

Multivariable adjusted odds ratios for GERD and flatulence across GDQS quintiles are presented in Table 4. In the crude model, participants in the highest quintile of GDQS had 20% higher odds of having GERD than subjects in the lowest one (OR: 1.20; 95% CI: 0.88–1.65, P trend = 0.508). This association remain non-significant after adjustments for age, energy intake, gender, physical activity, marital status, occupation, educational levels, WSI, BMI, smoking, depression, hypertension, diabetes, and cardiovascular events in model 3 (OR: 1.37; 95% CI: 0.97–1.93, P trend = 0.324). Similarly, participants in the highest quintile had no significant reduction in the probability of having flatulence in the crude model (OR: 0.94; 95% CI: 0.81–1.11, P trend = 0.578). After adjustment for potential confounders, this association remained non-significant in model 3 (OR: 1.02; 95% CI: 0.86–1.22, P trend = 0.664).

Table 1 General characteristics of study participants across quintiles of GDQS

Variables		Total (n = 6202)	Q1 (n = 1424)	Q2 (n = 1168)	Q3 (n = 1387)	Q4 (n = 1089)	Q5 (n = 1134)	P value*
GERD, yes (%)		383 (6.3%)	85 (1.4%)	77 (1.3%)	82 (1.3%)	59 (1%)	80 (1.3%)	0.506
Flatulence, yes (%)		2811 (46.3%)	662 (10.9%)	506 (8.3%)	642 (10.6%)	491 (8.1%)	510 (8.4%)	0.578
Depression, yes (%)		968 (16%)	255 (4.2%)	196 (3.2%)	232 (3.8%)	150 (2.5%)	135 (2.2%)	< 0.001
Diabetes, yes (%)		1296 (21%)	268 (4.3%)	253 (4.1%)	277 (4.5%)	220 (3.6%)	278 (4.5%)	0.058
Hypertension, yes (%)		1273 (21%)	345 (5.7%)	249 (4.1%)	267 (4.4%)	194 (3.2%)	218 (3.6%)	0.005
MI, stroke, ischemic, yes (%)		541 (8.9%)	156 (2.6%)	102 (1.7%)	117 (1.9%)	76 (1.3%)	90 (1.5%)	0.007
Smoking status (%)	**Never smoker**	4962 (81.6%)	1127 (18.5%)	945 (15.5%)	1114 (18.3%)	887 (14.6%)	889 (14.6%)	0.123
	Current smoker	704 (11.6%)	184 (3%)	129 (2.1%)	152 (2.5%)	108 (1.8%)	131 (2.2%)	
	Ex-smoker	414 (6.8%)	85 (1.4%)	65 (1.1%)	96 (1.6%)	78 (1.3%)	90 (1.5%)	
BMI (± SD)		28.19 ± 5.31	28.49 ± 4.91	28.33 ± 4.77	28.67 ± 8.03	28.81 ± 5.01	28.47 ± 5.66	0.045
Marriage (%)	Single	25 (0.4%)	5 (0.1%)	6 (0.1%)	7 (0.1%)	4 (0.1%)	3 (0.0%)	< 0.001
	Married	5887 (94.9%)	1301 (21%)	1101 (17.7%)	1329 (21.4%)	1052 (17%)	1104 (17.8%)	
	Widowed or Divorced	290 (4.7%)	118 (1.9%)	61 (1%)	51 (0.8%)	33 (0.5%)	27 (0.5%)	
Gender, male (%)		2615 (42.9%)	494 (8.1%)	462 (7.6%)	586 (9.6%)	500 (8.2%)	573 (9.4%)	< 0.001
Ooccupation, has job (%)		2403 (38.8%)	423 (6.8%)	402 (6.5%)	550 (8.9%)	473 (7.6%)	555 (9%)	< 0.001
Education (%)	Illiterate	1709 (17.4%)	415 (6.7%)	247 (4%)	203 (3.3%)	114 (1.8%)	100 (1.6%)	< 0.001
	Diploma and sub-diploma education	4184 (67.5%)	913 (14.7%)	774 (12.5%)	972 (15.7%)	751 (12.1%)	774 (12.5%)	
	University education	939 (15.1%)	96 (1.5%)	147 (2.3%)	212 (3.5%)	224 (3.6%)	260 (4.2%)	
WSI (± SD)		0.14 ± 0.73	−0.13 ± 0.74	0.06 ± 0.69	0.16 ± 0.69	0.31 ± 0.71	0.41 ± 0.69	< 0.001
Age (± SD)		48.48 ± 9.69	50.70 ± 10.42	49.43 ± 9.67	47.98 ± 9.67	47.08 ± 9.05	46.65 ± 8.67	< 0.001
Physical activity (MET. h/week)		40.74 ± 7.16	40.48 ± 7.24	40.51 ± 7.81	41.11 ± 7.34	40.75 ± 6.45	40.87 ± 6.77	0.128

BMI Body mass index

Values are means ± SDs

* Obtained from one way Anova for continuous variables and Chi-squared test for categorical variables

Discussion

To our best understanding, this is the first investigation on the association between GDQS adherence and GERD and flatulence. While previous studies have reported associations between diet quality and gastrointestinal conditions [10, 22, 23], our research did not find significant correlations between the highest adherence to the GDQS and the risk of GERD and flatulence among Iranian adults. This lack of significant findings may reflect the limitations of GDQS as a dietary assessment tool for these specific conditions, the complex interplay of nutritional components with gastrointestinal function, or underreporting dietary items, a common issue in self-reported questionnaires [24], may have influenced our results. For instance, the moderate cholesterol and salt values [25, 26] observed in the study (Table 3) could partly result from underreporting, especially considering the traditional dietary habits of this region [27].

Previous studies have shown significant associations between gastrointestinal conditions and dietary quality. For instance, adherence to the Dietary Approaches to Stop Hypertension (DASH) and Mediterranean diets has been linked to reduced odds of GERD and IBS symptoms [28–31]. However, most studies often focused on specific dietary components, whereas the GDQS reflects overall diet quality by including both protective and potentially problematic food groups, which may explain the lack of significant findings in this study. For example, Keshteli et al. [32], reported that more fruit intake had a lower chance of developing GERD; however, the vegetable consumption did not show a significant correlation with. Also results from a systematic review showed that minerals, polyphenols, fruits and fibers have beneficial effects to alleviate symptoms of IBS [33]. Moreover, in a cross-sectional study, Ping Wu et al. [34] showed that a high protein intake, carbohydrates, calories from protein (%), vitamin C, grains, potatoes, fruits, and eggs could reduce the risk of reflux esophagitis. In contrast, a high intake of meat, oils, salt, and calcium is linked to an elevated risk of reflux esophagitis. Buscail et al. [35] demonstrated that higher consumption of fatty and sugared products as a western dietary pattern can increase risk of IBS. A population-based cross-sectional study of Han Chinese showed that the consumption of meat was directly

Table 2 Food group intakes of study participants across quintile of GDQS

Dietary intakes	Q1	Q2	Q3	Q4	Q5	*P*-value#
Citrus fruits (gr/1000 kcal)	12.16 ± 14.73	17.65 ± 18.91	21.04 ± 21.33	24.0 ± 25.63	28.26 ± 25.81	< 0.001
Deep orange fruits (gr/1000 kcal)	8.48 ± 11.06	12.39 ± 14.34	15.04 ± 15.26	17.01 ± 15.50	12.56 ± 20.50	< 0.001
Other fruits (gr/1000 kcal)	79.54 ± 68.33	100.21 ± 74.52	111.61 ± 72.11	117.46 ± 74.15	130.56 ± 80.76	< 0.001
Dark green leafy vegetables (gr/1000 kcal)	4.51 ± 3.86	6.59 ± 6.67	7.74 ± 6.03	9.64 ± 7.69	12.93 ± 9.87	< 0.001
Cruciferous vegetables (gr/1000 kcal)	0.50 ± 1.16	0.83 ± 1.99	0.92 ± 2.51	1.28 ± 2.11	2.53 ± 18.35	< 0.001
Other vegetables (gr/1000 kcal)	58.15 ± 44.86	63.29 ± 49.55	72.98 ± 47.78	75.88 ± 55.45	78.56 ± 49.58	< 0.001
Legumes (gr/1000 kcal)	9.04 ± 7.79	10.74 ± 8.23	11.31 ± 8.13	12.12 ± 8.65	13.99 ± 9.66	< 0.001
Deep orange tubers (gr/1000 kcal)	1.99 ± 4.19	3.00 ± 5.50	2.98 ± 5.85	4.13 ± 6.75	4.66 ± 6.91	< 0.001
Nuts and seeds (gr/1000 kcal)	2.05 ± 4.33	3.33 ± 6.20	5.04 ± 7.18	6.43 ± 7.05	8.41 ± 7.18	< 0.001
Whole grains (gr/1000 kcal)	68.10 ± 91.84	70.26 ± 84.19	62.09 ± 72.00	65.66 ± 70.04	62.13 ± 62.11	0.029
Liquid oils (gr/1000 kcal)	4.03 ± 4.98	4.54 ± 4.70	4.91 ± 4.28	5.23 ± 4.23	5.79 ± 4.29	< 0.001
Fish and shellfish (gr/1000 kcal)	1.16 ± 1.70	1.57 ± 2.19	1.79 ± 2.27	2.14 ± 2.94	2.65 ± 2.75	< 0.001
Poultry and game meat (gr/1000 kcal)	4.28 ± 4.95	4.53 ± 4.10	5.00 ± 4.62	5.18 ± 4.86	5.73 ± 5.43	< 0.001
Eggs (gr/1000 kcal)	8.22 ± 7.90	8.80 ± 7.25	9.41 ± 7.79	9.57 ± 7.54	9.65 ± 7.00	< 0.001
High-fat dairy (gr/1000 kcal)	94.80 ± 75.97	104.62 ± 69.75	115.31 ± 70.32	112.07 ± 65.51	115.60 ± 56.72	< 0.001
Red meat (gr/1000 kcal)	12.80 ± 11.01	12.90 ± 9.28	13.36 ± 8.85	13.03 ± 8.93	12.87 ± 8.05	0.550
Processed meat (gr/1000 kcal)	0.66 ± 2.08	0.56 ± 1.45	0.55 ± 1.39	0.60 ± 1.07	0.53 ± 1.01	0.252
Refined grains and baked goods (gr/1000 kcal)	169.11 ± 85.83	157.69 ± 78.91	154.31 ± 73.72	146.04 ± 67.60	135.63 ± 65.69	< 0.001
Sweets and ice cream (gr/1000 kcal)	24.77 ± 17.76	21.66 ± 14.71	21.11 ± 13.86	20.19 ± 13.27	18.78 ± 12.47	< 0.001
Sugar-sweetened beverages (gr/1000 kcal)	15.63 ± 31.49	13.42 ± 25.97	12.49 ± 22.24	12.38 ± 19.34	10.76 ± 18.90	< 0.001
White roots and tubers (gr/1000 kcal)	45.24 ± 26.50	44.01 ± 25.48	43.38 ± 23.22	41.49 ± 22.06	42.03 ± 22.13	< 0.001
Juice (gr/1000 kcal)	7.71 ± 25.55	8.06 ± 20.01	7.78 ± 14.51	8.51 ± 20.37	7.72 ± 12.38	0.842
Purchased deep fried foods (gr/1000 kcal)	0.11 ± 0.47	0.10 ± 0.38	0.12 ± 0.44	0.15 ± 0.56	0.13 ± 0.40	0.120
Healthy items of GDQS (GDQS +) (gr/ 1000 kcal)	3.85 ± 1.43	4.79 ± 1.54	5.37 ± 1.52	5.83 ± 1.50	6.46 ± 1.54	< 0.001
Unhealthy in excessive amount items of GDQS (gr/ 1000 kcal)	0.91 ± 0.50	0.93 ± 0.44	0.92 ± 0.41	0.85 ± 0.36	0.84 ± 0.31	< 0.001
Unhealthy items of GDQS (gr/ 1000 kcal)	3.98 ± 2.01	3.43 ± 1.51	3.19 ± 1.31	2.93 ± 1.10	2.78 ± 0.94	< 0.001

P-values less than 0.05 were considered statistically significant

Table 3 Nutrient intakes of study participants across quintile of GDQS

Dietary intakes	Q1	Q2	Q3	Q4	Q5	*P*-value#
Energy (kcal)	2527.64 ± 893.08	2793.75 ± 847.15	2918.97 ± 793.32	3092.25 ± 754.90	3243.72 ± 709.40	< 0.001
Carbohydrate (gr/1000 kcal)	159.95 ± 15.76	158.30 ± 14.08	156.01 ± 13.21	155.81 ± 12.72	153.53 ± 13.20	< 0.001
Protein (gr/1000 kcal)	33.41 ± 5.03	34.02 ± 4.46	34.45 ± 3.98	34.45 ± 4.08	34.76 ± 3.81	< 0.001
Fat (gr/1000 kcal)	28.84 ± 6.37	29.48 ± 5.82	30.33 ± 5.35	30.57 ± 5.02	31.58 ± 5.38	< 0.001
Fiber (gr/1000 kcal)	14.99 ± 4.63	15.36 ± 4.00	15.07 ± 3.77	15.36 ± 3.63	15.36 ± 3.45	0.030
Salt (gr/1000 kcal)	1.57 ± 1.07	1.42 ± 1.05	1.42 ± 1.18	1.30 ± 1.32	1.24 ± 0.79	< 0.001
Cholesterol (mg/1000 kcal)	82.72 ± 45.63	86.68 ± 39.60	92.54 ± 42.91	91.87 ± 39.67	94.11 ± 38.09	< 0.001
Saturated fatty acid (gr/1000 kcal)	9.07 ± 2.56	9.11 ± 2.21	9.39 ± 2.17	9.15 ± 1.95	9.27 ± 1.90	< 0.001
Monounsaturated fatty acid (gr/1000 kcal)	10.37 ± 2.51	10.57 ± 2.33	10.75 ± 2.14	10.79 ± 2.00	11.20 ± 2.24	< 0.001
Polyunsaturated fatty acid (gr/1000 kcal)	5.73 ± 1.87	6.01 ± 1.80	6.22 ± 1.65	6.51 ± 1.62	6.83 ± 1.71	< 0.001
Calcium (mg/1000 kcal)	344.66 ± 107.33	361.26 ± 99.87	375.08 ± 97.42	372.69 ± 92.16	379.48 ± 80.94	< 0.001
Iron (mg/1000 kcal)	8.12 ± 1.78	8.07 ± 1.59	7.89 ± 1.47	7.93 ± 1.36	7.83 ± 1.26	< 0.001
Vitamin B6 (mg/1000 kcal)	0.72 ± 0.10	0.74 ± 0.09	0.75 ± 0.08	0.75 ± 0.09	0.75 ± 0.08	< 0.001
Folate (mcg/1000 kcal)	211.21 ± 31.41	211.62 ± 28.26	210.67 ± 27.16	210.75 ± 26.83	211.51 ± 29.58	0.896
Vitamin B12 (mcg/1000 kcal)	1.37 ± 0.81	1.47 ± 0.79	1.60 ± 0.92	1.59 ± 1.10	1.61 ± 0.72	< 0.001
Vitamin C (mg/1000 kcal)	30.56 ± 20.46	37.46 ± 22.08	41.66 ± 21.39	45.19 ± 24.19	52.08 ± 27.23	< 0.001
Vitamin A (mg/1000 kcal)	137.47 ± 81.28	162.64 ± 87.18	182.04 ± 104.76	198.72 ± 123.79	216.57 ± 100.65	< 0.001

P-values less than 0.05 were considered statistically significant

Table 4 Multivariable-adjusted odds ratio of the associations between GDQS with GERD and Flatulence

	Quintile of GDQS					P-trend
GERD	Q1	Q2	Q3	Q4	Q5	
Crude	1.00	1.12 (0.81–1.54)	0.99 (0.73–1.36)	0.90 (0.64–1.27)	1.2 (0.88–1.65)	0.508
Model1	1.00	1.19 (0.86–1.64)	1.09 (0.79–1.50)	1.03 (0.73–1.47)	1.42 (1.01–1.98)	0.254
Model2	1.00	1.15 (0.83–1.59)	1.01 (0.74–1.41)	0.96 (0.67–1.37)	1.28 (0.91–1.80)	0.438
Model3	1.00	1.19 (0.86–1.65)	1.05 (0.76–1.45)	1.01 (0.71–1.45)	1.37 (0.97–1.93)	0.324
Flatulence	Q1	Q2	Q3	Q4	Q5	
Crude	1.00	0.89 (0.76–1.04)	1.00 (0.86–1.15)	0.94 (0.81–1.11)	0.94 (0.81–1.11)	0.578
Model1	1.00	0.91 (0.78–1.07)	1.03 (0.89–1.21)	1.00 (0.85–1.19)	1.02 (0.87–1.21)	0.590
Model2	1.00	0.91 (0.77–1.07)	1.02 (0.87–1.20)	1.00 (0.84–1.20)	1.01 (0.85–1.19)	0.643
Model3	1.00	0.92 (0.78–1.08)	1.03 (0.88–1.21)	1.02 (0.86–1.21)	1.02 (0.86–1.22)	0.664

Model I: adjusted for age and energy intake

Model II: additionally adjusted for gender, physical activity, marital status, ooccupation, educational levels, WSI, and BMI

Model III: additionally adjusted for smoking status, depression, diabetes, hypertension, and cardio events

related with GERD [36]. On the other hand, in another cross-sectional study among Iranian adults, uninvestigated reflux positively correlated with either fast food consumption or traditional dietary patterns. However, no statistically significant associations between fast food, traditional, vegetarian, and Western dietary patterns and uninvestigated reflux were identified [37].

The GDQS metric highlights an increased consumption of food groups recognized for their protective effects against digestive health, such as vegetables, fruits, whole grains, legumes, and white meats, while decreasing intake of processed meats, refined grains, sweets, and beverages [11, 38]. However, some GDQS food groups, such as legumes and cruciferous vegetables, may contribute to gastrointestinal symptoms in some individuals, like increasing gas production [39]. Also, dairy products as a positive food group of GDQS may cause bloating in lactose-sensitive individuals [40]. Furthermore, this metric does not include certain food items influencing GERD risk, such as salt and spicy foods [13, 34]. This combination of protective and potentially problematic foods within GDQS may explain our findings' lack of a significant association observed in our study. Moreover, cultural dietary tendencies, such as high refined grain intake and low vegetable consumption typical in the region, may have influenced these results by modifying adherence to GDQS recommendations [26].

Beyond specific food groups, diet quality may impact gastrointestinal health through boarder mechanisms, such as modulating gut microbiota diversity [41] and reducing systematic inflammation [42]. High-quality diets, particularly those rich in fruits, vegetables, and whole grains, are associated with a balanced gut microbiome, which is critical in gastrointestinal function and modulation of inflammation [43]. Although these mechanisms suggest a protective role of diet on gastrointestinal health, the absence of a significant relationship in this study may reflect residual confounding or limitations of the GDQS in capturing dietary patterns relevant to GERD and flatulence, as it does not account for factors such as meal timing [44], portion size [45], and individual variations in gut microbiota [46]. Future longitudinal studies, including cohort designs and randomized clinical trials, are needed to clarify these associations and explore the role of unmeasured lifestyle and dietary factors.

This study has several strengths. It is the first comprehensive investigation with substantial sample size, delving into the association between GDQS and gastrointestinal conditions. We controlled for a wide range of potential confounders. However, it is essential to acknowledge the potential influence of residual confounders. Data collection was done via face-to-face interviews to increase the accuracy of data.

Nevertheless, certain limitations were considered in the interpretation of our results. Data on dietary assessment, GERD, and flatulence were collected through self-reporting, which has inherent limitations. For instance, the Food Frequency Questionnaire (FFQ) is a memory-based dietary assessment method that may lead to errors in reporting precise intakes. Since FFQs rely on self-reported data, they are subject to recall bias and inaccuracies in estimating portion sizes or food frequencies, potentially resulting in the misclassification of participants. Furthermore, mental health factors such as anxiety could influence gastrointestinal symptoms, was not measured and therefore could not be included as confounding variables. Moreover, our assessment of GERD did not account for the timing of symptom occurrence, such as possible reflux during post-meal sleep, which could affect the results. Also, the assessment of flatulence relied on a single question covering a one-year period, which may have captured isolated episodes rather than persistent or clinically significant symptoms. This could lead to an overestimation of prevalence, limiting the interpretation of the results. Additionally, certain food items that may impact gastrointestinal health, such as the consumption of carbonated beverages, were not included in the GDQS and, therefore, were not considered in our analysis. Also, the study's cross-sectional nature prohibits the establishment of a causal link between GDQS and GERD and flatulence due to the inherent challenge of temporality between exposure and outcome.

Conclusion

This study found no significant relationships between adherence to the Global Diet Quality Score (GDQS) and gastroesophageal reflux disease (GERD) and flatulence after adjusting for potential confounders. These findings highlight the complex relationship between diet quality and gastrointestinal health. For policymakers, these results emphasize the importance of considering multiple lifestyle factors in developing dietary guidelines and public health interventions to improve gastrointestinal health. To better understand findings, further studies employing prospective designs are required.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-21934-x.

Supplementary Material 1.

Supplementary Material 2.

Acknowledgements
We acknowledge the contribution of the participants and co-researchers.

Authors' contributions
FS.M wrote the manuscript. M.D. performed analysis. HM.Kh, S.FA, and S.Kh contributed to the study design. S.Kh critically revised the manuscript. All authors approved the final version of the manuscript.

Funding
This study is supported by Shahid Sadoughi University of Medical Sciences.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The Ethics Committee of Shahid Sadoughi Yazd University of Medical Sciences (IR.SSU.SPH.REC.1400.211) obtained ethical clearance to carry out the project. All individuals signed informed permission by the ethical principles of the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Research Center for Food Hygiene and Safety, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [2]Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [3]Prevention of Cardiovascular Disease Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [4]Department of Health in Emergencies and Disasters, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [5]Department of Nutrition, Shahid Sadoughi University of Medical Sciences, Shohadaye Gomnam BLD. ALEM square, Yazd, Iran.

Received: 15 May 2024 Accepted: 13 February 2025
Published online: 03 March 2025

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