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The Relationship between Functional Constipation and Major Dietary Patterns in Iranian Adults: Findings from the Large Cross-Sectional Population-Based SEPAHAN Study

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ABSTRACT: Although associations between dietary patterns and risk of chronic conditions have recently received increased attention, few studies have examined the relationship between major dietary patterns and risk of constipation. We collected dietary data using a validated dish-based, 106-item semi-quantitative Food Frequency Questionnaire on 4,763 adults aged 18∼55 years. Data on anthropometric measures were collected through self-administered questionnaires. Functional constipation was defined based on the Iranian validated version of Rome III. Factor analysis followed by a varimax rotation was applied to derive major dietary patterns from 39 predefined food groups, and logistic regression was used for association analysis. Three major dietary patterns were extracted: traditional (TD), fruit and vegetables dominant (FVD), and Western (WD). The association between TD and constipation was not significant for both genders and for the total sample. However, in the crude model and the fully adjusted model, poor adherence to the FVD was associated with a higher risk of constipation in men and in the total sample. In addition, we observed a significantly lower risk of constipation in the total sample and in female participants with low adherence to WD; however, this was not significant for male participants. Further studies in other populations, and future prospective studies, are required to reiterate these results.

Keywords: constipation, diet, food, gastroenterology, Iran

INTRODUCTION

Functional constipation (FC) is a major subgroup of functional gastrointestinal disorders (FGIDs) that are known as digestive system dysfunction. Digestive system disorders are categorized as chronic or recurrent in the absence of other pathologically based disorders (Talley, 2008). There is currently no known organic origin for functional constipation (Porter et al., 2011; Johnson et al., 2016). Constipation is a common public health problem with a well-recognized propensity to cause considerable discomfort and affect quality of life (Higgins and Johanson, 2004). Constipation represents a large public healthcare burden (Shau et al., 2016). In Iran, FC has a prevalence of 2.4∼11.2%, and the total 6-month cost of FC is estimated to be $147 purchasing power parity (Moghimi-Dehkordi et al., 2011).

Although several risk factors may contribute to FC, such as post-infection, psychosocial and mental health problems, and dietary habits are thought to play an important contributing role (Porter et al., 2011; Maguen et al., 2014; Riddle et al., 2016). Much attention has been focused on the benefits of dietary fiber (Campbell et al., 1993; Towers et al., 1994; Dukas et al., 2003; Sanjoaquin et al., 2004; Murakami et al., 2006; Murakami et al., 2007b), however, results to date are inconsistent. Studies have

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observed an association between constipation and dairy products (Sandler et al., 1990), beans (Sandler et al., 1990; Murakami et al., 2007a), meats, fruits, vegetables (Sandler et al., 1990), rice (Sandler et al., 1990; Wong et al., 1999; Nakaji et al., 2002; Murakami et al., 2006; Murakami et al., 2007a), eggs (Nakaji et al., 2002), confectionaries (Murakami et al., 2006; Murakami et al., 2007a), and some nonalcoholic beverages (Sandler et al., 1990; Wong et al., 1999; Sanjoaquin et al., 2004; Murakami et al., 2006). These epidemiological studies have demonstrated a relationship between diet and constipation, concentrating on the effects of individual nutrients or foods and food groups. However, in real life, people consume an array of different foods containing various nutrients rather than one specific type of food or a single nutrient.

The dominant approach for examining single nutrients or foods might not adequately account for complicated interactions and cumulative effects that may, in turn, result in drawing erroneous associations between dietary factors and disease (Okubo et al., 2007). To overcome this limitation, the dietary patterns approach or the measurement of overall diet, is now widely used to elucidate the relationship between diet and disease (Slattery et al., 1998; Newby and Tucker, 2004). Moreover, this approach potentially facilitates nutritional recommendations in both primary care settings and clinical situations.

Despite the importance of habitual dietary patterns in both healthy individuals and patients, to the best of our knowledge only a limited number of studies have focused on the relationship between dietary food patterns and constipation around the world. In addition, we are unaware of any published studies in Iran that have examined this association thus far. Due to its unknown etiology, diagnosis of constipation is conducted clinically, mainly through Rome III diagnostic criteria (Solhpour et al., 2008). By considering the impact of dietary patterns on chronic diseases, we hypothesized that different diets may influence FC. Accordingly, in the current study, we aimed to identify dietary patterns empirically in a large sample of Iranian adults using exploratory factor analysis, and to examine their associations with FC.

MATERIALS AND METHODS

Study design and population

This was a cross-sectional study conducted within the framework of the Study on the Epidemiology of Psychological Alimentary Health and Nutrition (SEPAHAN). The SEPAHAN study aimed to examine the relationship of epidemiologic dimensions of common gastrointestinal disorders with lifestyle factors and psychological disorders. Details of the study design, sample size, study participants, and data collection methods are reported elsewhere (Adibi et al., 2012). This study was performed on adults at 50 different health centers across the Isfahan province, central Iran. It was conducted in two main phases. In the first phase, demographic information, medical and family history, anthropometric measurements, questionnaires, and dietary factors were collected by sending requests to 10,087 individuals, of which 8,691 individuals returned completed questionnaires (response rate of 86.2%). The second phase was conducted just after phase 1, in which detailed information on individuals' gastrointestinal tract (GI) and psychological factors were collected from 4,763 complete questionnaires (response rate, 64.6%). All individuals who enrolled in the study before phase 1 provided written informed consent, and the study protocol was approved by the Regional Bioethics Committee of IUMS (#189069, #189082, and #189086), Isfahan, Iran (Adibi et al., 2012).

Dietary assessment

Dietary intakes in the preceding year were assessed using a 106-item dish-based, semi-quantitative Food Frequency Questionnaire (FFQ). To design this FFQ, the Willett-format FFQ was used. We included foods that were nutrient-rich, consumed reasonably often, or contributed to between-person variations from a comprehensive list of foods and mixed dishes. We focused on mixed dishes rather than their ingredients, along with specific foods. Related food items and mixed dishes were categorized together in one food group to shorten the list. In total, 106 foods or dishes were included in the questionnaire (Keshteli et al., 2014). To reduce the complexity of the data, the FFQ was grouped into five main components: (1) mixed dishes [cooked or canned (n=29)]; (2) all grain-based foods and potatoes (n=10); (3) dairy products [milk and dairy products, including butter and cream (n=9)]; (4) fruits and vegetables (n=22); and (5) miscellaneous food items and beverages [including sweets, fast foods, nuts, desserts, and beverages (n=36)]. The amount of eat food item consumed was determined by asking about the most popular serving units familiar to all people. Nine possible answers, from 'never or less than once a month' to '12 or more times/d', were provided for each question. However, this structure was not the same for all questions. For example, high-frequency items were omitted for fewer consumed foods but retained for foods consumed frequently. By using household measures, all food items were converted to grams per day (g/d) (Ghafarpour et al., 1999), and daily energy and nutrient intakes were estimated using the United States Department of Agriculture (USDA)'s food composition database. Foods were categorized into 39 food groups based on the similarity of nutrients content to define dietary patterns (Table 1) (Hosseinzadeh et al., 2016). Some food items were individually allocated in a food group because of

Table 1. Factor loading matrix for the extracted major dietary patterns

Food groups	Dietary patterns		
	Traditional	Fruit and vegetables dominant	Western
Meat	**0.87**	–	–
Processed meat		–	**0.54**
Organ meat		–	**0.31**
Fish	**0.29**	–	–
Poultry	**0.41**	–	
Eggs	**0.43**	–	–
Butter	–	–	**0.24**
Low fat dairy	–	**0.46**	–
High fat dairy	–	–	**0.47**
Tea	–	–	–
Coffee	–	–	**0.23**
Fruit	–	**0.64**	–
Citrus fruit	–	**0.63**	–
Fruit juice	–		**0.30**
Onions	**0.60**		–
Non flatulent vegetables	0.48	**0.52**	–
Flatulent vegetables	–	**0.59**	–
Legumes	**0.61**	–	–
Whole grains		**0.20**	–
Refined grains	**0.28**	–	–
Snacks	–	–	**0.47**
Nuts	–		**0.31**
Mayonnaise	–	–	**0.30**
Dried fruit		**0.32**	–
Sweet dessert	–	–	**0.51**
Chocolate	–	–	**0.39**
Hydrogenated fat	**0.36**	–	
Vegetable oil	**0.89**	–	–
Sugars	–	–	**0.30**
Condiments	–	–	**0.20**
Tomato		**0.52**	–
Carbonated drinks	–	–	**0.45**
Pickles	–	–	**0.32**
French fries	**0.78**	–	–
Salt	**0.85**	–	–
Cocoa milk	–	–	**0.24**
Potato	**0.34**	–	–
Soy	**0.40**	–	–
Chili peppers	**0.64**	–	–

Eigenvalues >0.2 were considered to label the identified patterns. Bold values are the main components of each factor.

their unique nutrient contents or their contribution to a specific dietary pattern (Haghighatdoost et al., 2020). Because the quantification of portion sizes helps with better ranking of individuals in terms of their dietary intakes (Cade et al., 2004), the most consumed portion sizes for each item in the general population were used for mixed dishes in this study. The frequency response categories differed between foods frequently and infrequently consumed. For foods consumed infrequently, we ignored the high-frequency categories. All food items were computed and converted into g/d using household scales. Daily nutrient intakes for each individual were calculated according to the USDA national nutrient databank (Haghighatdoost et al., 2019). Individuals whose total energy intake was outside the range of 800 to 4,200 kcal/d were excluded from the study to reduce underestimation and overestimation impacts (Fung et al., 2002). As a result, data from 3,846 individuals were included in the statistical analysis. After food grouping, dietary patterns were empirically derived using exploratory factor analysis. Details regarding the design, food categories, and reliability and validity of dish-based, semi-quantitative FFQ have been described elsewhere (Keshteli et al., 2014).

Assessment of constipation

In this study, a modified Iranian validated version of Rome III criteria was used to diagnose functional gastrointestinal disorders (Adibi et al., 2012; Masaeli et al., 2013). The modified version consists of six major domains, with functional oesophageal disorders and functional GI disorders included in the questionnaire for adults. Each domain contained several questions to aid the diagnosis of these disorders based on the Rome III criteria (Keshteli et al., 2017). According to the Rome III criteria, constipation was defined as the presence of at least one or two of the following symptoms, for at least three months, with onset at least six months preceding this study:

1. Straining during at least 25% of defecations (at least often).
2. Lumpy or hard stools in at least 25% of defecations (at least often).
3. Sensation of incomplete evacuation in at least 25% of defecations (at least sometimes).
4. Sensation of anorectal obstruction/blockage in at least 25% of defecations (at least sometimes).
5. Manual maneuvers to facilitate at least 25% of defecations (e.g., digital evacuation, support of the pelvic floor) (at least sometimes).
6. Fewer than three defecations per week (at least often) (Pourhoseingholi et al., 2009).

Assessment of other variables

Self-administered questionnaires were used to collect information on age (years), sex (male and female), marital status (married and single), education level [under diploma, diploma (12-year formal education), and collegiate], and anthropometric measures, including weight, height, weight, and body mass index [BMI=weight (kg)/height square (m^2)]. Smoking, physical activity (Haghighatdoost et al., 2019), and stressful life events (SLE) over the past six months were assessed by using a validated SLE questionnaire (Roohafza et al., 2011; Haghighatdoost et al., 2019). The total score ranged from 0 to 83, with higher scores indicating more intensity of perceived stressors

(0=never, 1=very mild, 2=mild, 3=moderate, 4=severe, and 5=very severe). This score was treated as a continuous covariate in the statistical analysis. More details of SLE scores are provided elsewhere (Roohafza et al., 2011). Based on self-reported smoking habits, participants were divided into three categories "non-smokers", "ex-smokers", or "current smokers". General Practice Physical Activity Questionnaire were used to assess physical activity levels. Individuals with physical activity levels of one hour per week were considered active. The General Health Questionnaire 12-item (GHQ-12) was also concurrently applied with the stressful life event questionnaire. In this questionnaire, each item is rated on a 4-point scale (less than usual, no more than usual, fairly more than usual, or much more than usual) (Goldberg and Hillier, 1979; Montazeri et al., 2003). The GHQ score method (0-0-1-1 method) was used to score the questionnaires. In this way, participants could score between 0 and 12, with a cutoff point of 4 considered for high and low stress (Roohafza et al., 2011).

Statistical methods

Dietary patterns were categorized based on 39 food groups, derived from exploratory factor analysis by the principal component analysis extracting method (Table 1). Factors were rotated by varimax rotation. Orthogonal transformation was used to obtain factors with simple structures. The interpretability of factors, eigenvalues (>2), and Scree tests were used to determine which factors should be retained. Correlations between each item and derived dietary pattern profiles were determined using factor loadings with a cutoff value of 0.2. Identified factors were labeled based on the items highly loaded in each factor. For dietary patterns, according to the Scree plot, eigenvalues substantially dropped out after the third and slightly changed for each other factor after the fourth. Therefore, these three factors were considered major dietary patterns and were labeled based on our interpretation of the data and the earlier literature. Factor scores of dietary patterns for each participant were calculated by summing intakes of foods weighed by their factor loading. We computed age-, gender-, and energy-adjusted intakes of food groups using analysis of covariance (ANCOVA). To identify significant differences in general characteristics, we used an independent-samples *t*-test and a chi-squared test for continuous and categorical variables, respectively. Crude and multivariable-adjusted odds ratios and 95% confidence intervals (CIs) for the frequency and severity of GI symptoms were calculated by ordinal logistic regression. Proportional odds assumption as a prerequisite condition for conducting ordinal logistic regression was examined using a chi-squared test. All models were the same as described above for binary logistic regression. $P<0.05$ (two-sided) was considered statistically significant. To investigate the association between dietary patterns and constipation, we calculated logistic regression of the crude and adjusted models (four models). In the first model, adjustments were made for age (continuous), sex, and energy intake (continuous). In the second, we further controlled for marital status (single/married), education (under diploma/diploma/collegiate), and in the third we additionally adjusted for smoking status (non-smoker, ex-smoker, and current smoker), physical activity (<1 h/d and ≥1 h/d) and BMI ("being normal" was defined as BMI 18.5 to 25.0 kg/m^2; "being overweight" was defined as BMI 25.0 to 29.9 kg/m^2; and "being obese" was defined as BMI ≥30.0 kg/m^2). In addition, the fourth model was adjusted for GHQ and SLE. All statistical analyses were conducted using the Statistical Package for Social Sciences (version 16.0 for Windows, SPSS Inc., Chicago, IL, USA).

RESULTS

This large population-based study demonstrates a range of major dietary patterns are associated with constipation in the Iranian population. According to scree plots and eigenvalue >2 identified by factor analysis, there are three major dietary patterns in Iran: the traditional dietary pattern (TD), the fruit and vegetables dominant dietary pattern (FVD), and the Western dietary pattern (WD).

Table 1 presents the factor loading matrix used in this study. The factors were labeled based on food groups, which were highly loaded. The TD pattern was loaded with vegetable oil, meat, salt, French fries, chili pepper, legumes, onions, egg, poultry, soy, hydrogenated fat, potato, fish, and refined grains. The FVD pattern was loaded with fruits, citrus fruits, flatulent vegetables, tomato, non-flatulent vegetables, low-fat dairy, dried fruits, and whole grains. The WD pattern was loaded with processed meats, sweet desserts, high-fat dairy, snacks, carbonated drinks, chocolate, pickles, organ meats, nuts, sugar, mayonnaise, fruit juice, butter, cocoa milk, coffee, and condiments. Other identified dietary patterns were responsible for a slight variance, and therefore were not considered in the subsequent analysis.

Table 2 shows the general characteristics of participants, and dietary patterns in participants with and without constipation. Compared to participants without constipation, those with constipation are more likely to be female ($P<0.001$), have higher BMIs (overweight and beyond) ($P=0.03$), have higher GHQ scores, have higher total stressor severity (TSS) scores ($P<0.001$), and be less active ($P<0.001$). Participants who consumed FVD less than the median frequency were more likely to have constipation ($P<0.001$).

Table 3 shows the basic information of study partici-

Table 2. General characteristics of participants by two levels (less than and higher than median) of dietary patterns and constipation

Variables	Constipation		*P*-value
	Yes (n=1,591)	No (n=3,172)	
Age	36.56±7.95	36.58±8.16	0.92
BMI	25.28±4.88	24.97±4.51	0.03
Total stressors severity score	36.27±21.87	24.89±17.52	<0.001
GHQ score	3.02±3.12	1.60±2.38	<0.001
Sex			<0.001
Male	523 (24.8%)	1,583 (75.2%)	
Female	1,068 (40.2%)	1,589 (59.8%)	
Smoking			0.27
Quit smoking	57 (29.1%)	139 (70.9%)	
Have not smoked yet	1,289 (33.4%)	2,567 (66.6%)	
Current smoker	45 (29.4%)	108 (70.6%)	
Physical activity			<0.001
1 h/d	862 (31.7%)	1,856 (68.3%)	
<1 h/d	617 (37.2%)	1,042 (62.8%)	
Marital status			0.29
Married	1,275 (33.8%)	2,501 (66.2%)	
Single	279 (31.9%)	595 (68.1%)	
Education level			0.78
Under diploma	221 (34.6%)	417 (65.4%)	
Diploma (12-year formal education)	440 (32.6%)	908 (67.4%)	
Collegiate	884 (33.4%)	1,766 (66.6%)	
Traditional dietary pattern			0.2
Less than median	582 (34.6%)	1,099 (65.4%)	
More than median	547 (32.5%)	1,134 (67.5%)	
Fruit and vegetables dominant dietary pattern			0.01
Less than median	598 (35.6%)	1,083 (64.4%)	
More than median	531 (31.6%)	1,150 (68.4%)	
Western dietary pattern			0.04
Less than median	592 (35.2%)	1,089 (64.8%)	
More than median	537 (31.9%)	1,144 (68.1%)	

Continuous variables are reported as mean±SD while categorical variables are reported as frequency (percentage).
Resulted from independent samples *t*-tests and chi-squared tests for continuous and categorical variables, respectively.
BMI, body mass index; GHQ, General Health Questionnaire.

pants by category of their major dietary patterns. Participants who adhered largely to the TD were more likely to be female ($P<0.001$), physically active ($P=0.007$), and more educated ($P<0.001$). Individuals who largely followed the TD and FVD were more likely to have never smoked ($P<0.001$ and 0.06, respectively). Furthermore, women in both the 'less than median' and 'more than median' groups consumed a higher amount of fruit and vegetables than men ($P<0.001$). Furthermore, 66.5% of participants who consumed the FVD had ≥1 h/d physical exercise ($P<0.001$). In addition, higher levels of education were correlated with lower incidences of constipation in the FVD group ($P<0.001$). Participants were more likely to follow WD as their staple dietary pattern if they were female ($P=0.01$), married ($P=0.01$), and had a higher level of education ($P<0.001$). Moreover, age, GHQ scores, and TSS were significantly ($P<0.001$) associated with the FVD. Age ($P<0.001$), BMI ($P<0.001$), and GHQ scores ($P=0.004$) were also significantly associated with the WD, and participants in the 'more than median' column had a higher association with GHQ and were more likely to be less than 36 years old, compared to the 'less than a median' column.

Table 4 presents the distribution of the nutrient intakes of participants across the different categories of the FVD, TD, and WD. No significant differences were observed in nutrient intake between those in the higher and lower distributions of any of the dietary patterns (all $P>0.05$).

Crude and multivariable-adjusted odds ratios and 95% CIs for having constipation across the three major dietary patterns for people who consumed 'less than the median' compared with 'more than the median' for both male and females, and all participants are shown in Table 5. No statistically significant associations were found between TD and constipation. However, lower adherence to FVD was directly associated with a higher risk of constipation in the crude model (OR=1.49, $P=0.002$) and in the fully adjusted model 3 (OR=1.41, $P=0.03$) for men, but not for women. In our study, the association analysis for total participants showed that those who consumed

Table 3. General characteristics of participants by categories of dietary patterns

Variables	Traditional dietary pattern			Fruit and vegetables dominant dietary pattern			Western dietary pattern		
	Less than median	More than median	*P*-value	Less than median	More than median	*P*-value	Less than median	More than median	*P*-value
Age	36.05±7.68	36.53±8.04	0.09	35.47±7.56	36.82±8.11	<0.001	37.40±7.77	35.53±7.90	<0.001
BMI	25.01±4.17	25.03±4.74	0.89	25.02±4.74	25.02±4.18	0.99	25.37±4.74	24.67±4.15	<0.001
GHQ score	2.16±2.75	1.99±2.64	0.06	2.32±2.88	1.82±2.49	<0.001	1.93±2.61	2.21±2.78	0.004
Total stressors severity score	28.02±18.93	28.50±19.45	0.46	29.76±19.86	26.76±18.38	<0.001	28.06±19.20	28.44±19.18	0.59
Sex			<0.001			<0.001	666 (39.6%)	737 (43.8%)	0.01
Male	581 (34.6%)	822 (49%)		777 (46.2%)	626 (37.2%)		1,015 (60.4%)	944 (56.2%)	
Female	1,100 (65.4%)	859 (51%)		904 (53.8%)	1,055 (62.8%)		1,373 (83.4%)	1,317 (80%)	
Marital status			0.83			0.2	273 (16.6%)	330 (20%)	0.01
Married	1,339 (81.5%)	1,351 (82%)		1,357 (82.5%)	1,333 (80.8%)		906 (58.8%)	984 (62.3%)	
Single	303 (18.5%)	300 (18%)		287 (17.5%)	316 (19.2%)		636 (41.2%)	595 (37.7%)	
Physical activity			0.007			<0.001	53 (3.5%)	69 (4.6%)	0.04
1 h/d	909 (58.2%)	981 (63%)		848 (54.6%)	1,042 (66.5%)		1,405 (93.4%)	1,371 (92.2%)	
<1 h/d	653 (41.8%)	578 (37%)		706 (45.4%)	525 (33.5%)		47 (3.1%)	47 (3.2%)	
Smoking			<0.001			0.06	243 (14.8%)	153 (9.3%)	0.3
Quit smoking	39 (2.6%)	83 (5.5%)		66 (4.4%)	56 (3.7%)		459 (28%)	426 (25.9%)	
Have not smoked yet	1,416 (95%)	1,363 (90.5%)		1,368 (91.8%)	1,408 (93.8%)		938 (57.2%)	1,067 (64.8%)	
Current smoker	34 (2.4%)	60 (4%)		57 (3.8%)	37 (2.5%)		37.40±7.77	35.53±7.90	
Education level			<0.001			<0.001	25.37±4.74	24.67±4.15	<0.001
Under diploma	172 (10.5%)	224 (13.6%)		232 (14.2%)	164 (9.9%)		1.93±2.61	2.21±2.78	
Diploma (12-year formal education)	395 (24.1%)	490 (29.8%)		475 (29%)	410 (24.9%)		28.06±19.20	28.44±19.18	
Collegiate	1,075 (65.5%)	930 (56.6%)		930 (56.8%)	1,075 (65.2%)		666 (39.6%)	737 (43.8%)	

Continuous variables were reported as mean±SD, while categorical variables were reported as frequency (percentage).
Resulted from independent samples *t*-tests and chi-squared tests for continuous and categorical variables, respectively.
BMI, body mass index; GHQ, General Health Questionnaire.

Table 4. Dietary intakes by two levels (less and higher than median) of major dietary patterns

Variables	Traditional dietary pattern			Fruit and vegetables dominant dietary pattern			Western dietary pattern		
	Less than median	More than median	*P*-value	Less than median	More than median	*P*-value	Less than median	More than median	*P*-value
Total dietary fiber	23.20±9.94	22.82±9.72	0.34	22.86±10.06	23.16±9.59	0.47	23.07±9.83	22.95±9.84	0.76
Energy (kcal)	2,459.28±835.96	2,394.25±847.63	0.06	2,407.55±869.56	2,446.60±813.52	0.26	2,424.58±843.18	2,429.26±841.66	0.89
Caffeine	98.37±88.24	100.73±98.80	0.54	96.62±88.02	102.51±98.93	0.12	96.94±87.60	102.09±99.13	0.18
Carbohydrates	306.77±116.97	298.98±118.94	0.11	301.53±122.36	304.28±113.44	0.57	302.40±117.69	303.38±118.33	0.84
Fats	100.52±37.94	97.86±37.70	0.08	97.84±38.20	100.56±37.62	0.08	99.27±37.86	99.12±37.83	0.92
Protein	90.25±34.10	87.93±34.16	0.10	88.50±34.70	89.71±33.57	0.39	89.00±34.33	89.20±33.98	0.88
Folate food	325.18±130.44	321.14±125.25	0.44	319.93±127.56	326.45±128.16	0.21	325.37±127.28	321.02±128.46	0.41
DHA	0.22±0.23	0.23±0.23	0.39	0.22±0.24	0.23±0.22	0.67	0.22±0.23	0.23±0.23	0.44
EPA	0.06±0.07	0.07±0.07	0.37	0.06±0.08	0.07±0.07	0.68	0.06±0.07	0.07±0.07	0.46

Values are mean±SD.
Resulted from ANCOVA (all parameters by energy intake were adjusted for age, gender, and energy intake; energy intake was adjusted for age and gender).
Energy was considered as the absolute amount per day.

'less than the median' amounts of fruit and vegetables have almost 23% higher odds of constipation in fully adjusted model 3 (OR=1.23, *P*=0.026) than those who eat 'more than the median'. However, lower consumption of processed meats, sweet desserts, and carbonated drinks ('more than median') was associated with decreased risk of constipation in the crude model (OR=0.86, *P*=0.04) and in model 3 (OR=0.83, *P*=0.04) for all participants. Although we did not find a significant association between the WD and constipation males, for females, lower level consumption from the WD significantly decreased the risk of constipation in both the crude (OR=0.83, *P*=0.04) and fully adjusted (OR=0.78, *P*=0.03) models.

DISCUSSION

To the best of our knowledge, this is the first comprehensive factor analysis study to evaluate the association between dietary patterns and constipation in Iran. Three major dietary patterns (TD, FVD, and WD) were predominantly categorized in this study. In the large included cohort of Iranian adults, we found a significant inverse association between adherence to FVD 'less than the median' and a lower likelihood of constipation. Furthermore, patients with the disease had a higher odd of being female, having a BMI>24.9, having higher GHQ and TSS scores, and adhering to lower levels of activity (*P*<0.001).

The present study revealed three major dietary patterns in a large population of Iranian adults. Iran is a Middle Eastern country in which the majority of its population, particularly those living in urban areas, have experienced a rapid nutrition transition in recent years, characterized by adopting Western-style unhealthy dietary patterns (i.e., high-fat dairy products, refined grains, red or processed meats, sweets, salty snacks, and fried potatoes) instead of traditional healthy ones (i.e., diets rich in fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains) (Ghassemi et al., 2002; Mehio Sibai et al., 2010). Notably, during this period, there was a rapid rise in the prevalence of major diet-related non-communicable diseases, such as obesity, cardiovascular disease, and diabetes mellitus among Iranian adults (Mohammadi et al., 2005; Esteghamati et al., 2009; Mehio Sibai et al., 2010; Sharifi et al., 2015; Shirzadi et al., 2019).

Women had a higher risk of any FC than men. Our results are consistent with those from Thompson et al. (2002) which showed a higher prevalence of FC in females in Canada and other studies, including an Iranian population-based study that demonstrated a higher prevalence of FC in women (Pare et al., 2001; Wei et al., 2001; Lau et al., 2002; Delvaux, 2003; Karaman et al., 2003; Si et al., 2003; Bommelaer et al., 2004; Celebi et al., 2004; Chang, 2004; Kang, 2005; Sperber et al., 2005; Roshandel

Table 5. Multivariable-adjusted odds ratio (OR) and 95% confidence interval (CI) for the association between dietary patterns and constipation in participants of both genders and the total sample

	Male			Female			Total		
	OR	95% CI for OR	P_{trend}	OR	95% CI for OR	P_{trend}	OR	95% CI for OR	P_{trend}
Traditional dietary pattern									
Curd	0.99	0.77～1.27	0.97	0.99	0.82～1.19	0.95	1.10	0.95～1.26	0.20
Model 1	1.01	0.99～1.03	0.18	1.00	0.99～1.01	0.47	1.01	0.86～1.18	0.85
Model 2	1.01	0.99～1.03	0.11	1.00	0.99～1.02	0.38	0.96	0.80～1.14	0.65
Model 3	1.01	0.99～1.03	0.15	1.00	0.98～1.02	0.65	0.96	0.80～1.15	0.69
Fruit and vegetables dominant dietary pattern									
Curd	1.49	1.16～1.91	0.002	1.18	0.98～1.41	0.06	1.20	1.03～1.38	0.014
Model 1	1.45	1.10～1.92	0.008	1.13	0.93～1.38	0.19	1.24	1.05～1.45	0.007
Model 2	1.59	1.17～2.15	0.003	1.16	0.93～1.45	0.17	1.28	1.07～1.50	0.006
Model 3	1.41	1.02～1.95	0.03	1.07	0.84～1.35	0.56	1.23	1.06～1.39	0.026
Western dietary pattern									
Curd	1.02	0.77～1.26	0.92	0.83	0.69～0.99	0.04	0.86	0.74～0.99	0.04
Model 1	1.04	0.72～1.25	0.74	0.83	0.69～1.02	0.07	0.87	0.74～1.02	0.09
Model 2	1.07	0.69～1.25	0.65	0.86	0.69～1.07	0.17	0.88	0.73～1.05	0.15
Model 3	1.10	0.66～1.25	0.58	0.78	0.62～0.98	0.03	0.83	0.68～0.99	0.04

Resulted from Mantel-Haenszel extension chi-squared tests.
Model 1, adjusted for age, gender, marital status, education, and energy intake (kcal); Model 2, additional adjustment for physical activity, smoking, and body mass index; Model 3, additional adjustment for stressful life events and General Health Questionnaire.

et al., 2006). Nevertheless, other studies conducted in Taiwan, India, and Iran (among university students) reported a similar prevalence of FC among men and women (Ho et al., 1998; Shah et al., 2001; Lu et al., 2003; Gwee et al., 2004; Ghannadi et al., 2005). Furthermore, Talley et al. (1993) did not find an association between gender and FC. This differs from most other studies, which have found that FC rates are higher in women (Sandler et al., 1990; Campbell et al., 1993; Pare et al., 2001). In addition, in the study by Sandler et al. (1990) conduction in the US, no association was found between FC and level of education.

There is presumably an association between a higher BMI, low level of education, and constipation in Iranian women. Approximately 60% of constipated patients have a BMI≥25 (Campbell et al., 1993), however, no studies have yet investigated this relationship in the overall population of Iran (including men). No significant differences in energy and macronutrient intake were observed across any of the dietary patterns. However, age, GHQ score, and TSS were significantly associated with the FVD. Furthermore, age, BMI, and GHQ scores for participants consuming the WD were significantly associated with constipation. Indeed, participants in the ‘more than median’ column for WD had higher GHQ scores and were more likely to be in the standard range for BMI (<25) and be less than 36 years old, compared with the ‘less than the median’ column. The highest factor loading scores for the three dietary patterns were given to vegetable oil (0.89), meat, and salt (0.85), all from TD. Moreover, the lowest factor loading scores (eigenvalues ≤2) were given to condiments and pickles (WD) and whole grain (FVD).

Environmental factors play a crucial role in the etiology of constipation. Therefore, studies have investigated the relationship between constipation and lifestyle behaviors, such as an unhealthy diet, smoking and lack of exercise (Sandler et al., 1990; Campbell et al., 1993; Rajindrajith and Devanarayana, 2011). For example, population-based studies have indicated that obesity is associated with a range of chronic GI consequences, many of which result in functional GI disorders, such as constipation (Aro et al., 2005; van Oijen et al., 2006). Another study suggested that a higher intake of fast foods and a lower intake of vegetables may contribute to an increased risk of constipation. The importance of healthy meals containing a high proportion of vegetables and that minimize fast foods reduce constipation (Shau et al., 2016). Most available data on constipation is from developed countries compared with developing countries (Gwee et al., 2013). Indeed, there is a paucity of data on constipation from the Middle East (Suares and Ford, 2011).

However, the cross-sectional design of the current study poses limitations in investigating causality. Cross-sectional designs do not allow for determining whether constipation causes healthy dietary intakes or if the healthy diet precedes the prevention of constipation. Moreover, limitations in determining dietary patterns should be considered. The arbitrary decision to identify dietary patterns by food grouping and the rotation method may influence results. Nevertheless, studies have shown that determining dietary patterns by using individual food components instead of food groups and via oblique rotation instead of orthogonal rotation does not identify different dietary patterns. Furthermore, dietary patterns might be influenced by demographic characteristics such as age, sex, and education level; therefore, our results may not be applicable to other populations. In the current study, we retained some dietary patterns with factor loading of less than 0.2, which may affect the stability of the extracted factors. In addition, using self-reported data may lead to misclassification. Despite these limitations, the current study provides data on the association between dietary patterns and constipation in a large sample of the Iranian population. The benefits of assessing dietary patterns include detecting the combined effects of foods and nutrients, particularly when each component of a pattern has only a tiny contribution to the risk and nutrients-related disorders. However, because patients were sampled from the general population, selection biases that might apply to a specialist or hospital-derived sample could not arise. Although all the participants live in the Isfahan province, and therefore our data may not represent the entire Iranian population, the large sample size serves as the study's strength. In the study, face-to-face interviews were conducted, and all subjects were requested to fill in questionnaires assisted by trained health personnel who could provide a relatively precise interpretation of the items in the questionnaire. Moreover, this is the first study to examine the relationship between dietary patterns and constipation. Further prospective studies considering the role of other relevant confounders and mediators of this association are required to confirm our findings.

In conclusion, this cross-sectional study has provided evidence to support that TD is not significantly associated with constipation. Having a diet which is poor fruit and vegetables increases the risk of constipation, and poor adherence to the WD is associated with a lower risk of constipation.

AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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