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Fluid Intake and Functional Gastrointestinal Disease: A Narrative Review

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ABSTRACT

Background: Functional Gastrointestinal Diseases (FGIDs) impose a huge health burden, and lead to metabolic and mental disorders, impaired social function and productivity, reduced quality of life, higher total mortality and health care cost. Beverages are one of the major components of habitual dietary habits that may influence the symptoms of FGIDs.

Objective: The purpose of this study was to review the effect of frequent dietary fluids on common causes of FGIDS including functional dyspepsia (FD), irritable bowel syndrome (IBS), gastroesophageal reflux disease (GERD) and functional constipation (FC).

Methods: A literature search was done using the following search engines: PubMed, Google Scholar and ISI web of science with the following search terms "beverages", tea", "caffeine", "coffee", "milk", "water", "fruit juice", "carbonated beverage", "constipation", "irritable bowel syndrome", "gastroesophageal reflux disease", "dyspepsia",.

Results: In this review, 85 studies were evaluated. It was shown that to higher intakes of caffeinated drinks, fruit juice, milk, soft drinks and carbonated beverages are associated with aggravating symptoms in GERD, IBS and FD. The data on the relation between water consumption with GERD, IBS and FD are limited and inconsistent. However, consumption of fruit juices and water was related to an improvement in constipation.

Conclusion: Fluid intake can be effective in the management of FGIDs symptoms. However, further investigation on the role of various fluids consumption on symptoms of FGIDS is required.

Key words: Functional Gastrointestinal Disease, Water, Fluid, Beverages, Juice

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Introduction

Functional gastrointestinal diseases (FGIDs), also known as disorders of gut-brain interactions (DGBIs), comprise groups of the chronic and cyclical abdominal symptom without a marked organic cause and motility disorder *[1]*. FGIDs include functional constipation (FC), irritable bowel syndrome (IBS), gastroesophageal reflux disease (GERD), functional dyspepsia (FD), diarrhea, gastroparesis and fecal Incontinence. FGIDs impose a huge health burden and may lead to metabolic and

mental disorders, impaired social function and productivity, reduced quality of life, higher total mortality and health care cost *[2]*. Routine diagnosis of these disorders is made by medical history, physical examination, and symptoms defined by ROME criteria *[3]*. The Rome IV criteria indicate that approximately 35% of people suffer from at least one FGID *[4]*. The etiology of FGIDs is not clearly understood but there is evidence for physiological and morphological changes in the gastrointestinal tract and central nervous system (CNS) *[5]*.

Besides psychosocial and physiological risk factors, dietary habits are the main lifestyle determinants of FGIDs risk or their symptoms *[6, 7]*. Previous epidemiologic studies have suggested some restricting diets as treatment recommendations for patients with FGIDs *[8]*. Beverages are one of the major components of dietary habits, and their type can influence risk of chronic diseases such as cardiovascular disease *[9]*, metabolic diseases *[10]*, kidney diseases *[11]*, neuropsychological disorders *[12]* and colorectal cancer *[9]*. Types, quality and quantity of consumed beverages are affected by different factors including culture, diseases, individual characteristics and environment *[13-15]*. Adults consume 3 to 4 Liters of fluid per day, which come from plain solid food, coffee, milk, water, fruit juice, tea, soda and alcoholic beverages *[16]*. The consumption of coffee, tea and alcoholic beverages is one of the oldest and most changeable dietary behaviors, e li hw sugar-sweetened beverages (SSB) intake is almost new and prevalent around the world *[17]*. Some epidemiological studies indicated that the amount and the type of fluid intake may be linked to development of GI diseases and improve or worsen their symptoms *[18, 19]*. However, to date, limited data is available on the relation between usual fluid intake and prevalent FGIDS. Considering the heterogeneous results in previous studies and the lack of a narrative review on this topic, this study investigated the role of frequent fluids consumption on some FGIDS including FD, FC, GERD, and IBS.

Materials and Methods

A literature search was performed using the scientific databases: Google Scholar, PubMed and ISI web of science The following search terms including tea", "dyspepsia", "coffee", "milk", "water", "fruit juice", "irritable bowel syndrome", "beverages", "carbonated beverages", "caffeine", "constipation", "gastroesophageal reflux disease". The search was further limited to include humans, Articles published in English. In this narrative review, 85 studies were included that 7 studies were about coffee and irritable bowel syndrome (IBS), 6 studies were about coffee and gastroesophageal reflux disorder (GERD), 5 studies were about coffee and functional dyspepsia (FD), 4 on coffee and functional constipation (FC), 6 studies on milk and IBS and GERD, also separately 3 studies on milk with FD and FC, 2 studies on fruit juice and IBS, 7 studies on fruit juice and GERD, 2 studies on fruit juice and FD and FC, 4 studies on soft drinks in association with IBS and FD, 3 studies on soft drinks and GERD, 5 studies on water in relation with IBS and FD, 3 studies on water and GERD, 6 studies on water and FC, 4 studies on carbonated beverages and IBS, 6 studies on carbonated beverages and GERD, and 3 studies on carbonated beverage and FD.

Coffee and functional gastrointestinal disorders

Coffee, especially caffeinated coffee has been shown to stimulate colonic motor activity and gastric acid secretion in healthy subjects *[20]*. Coffee has also been reported to increase recto-sigmoid motor activity and induce laxative effect in susceptible individuals *[21]*. Restricted intake of coffee was suggested in symptoms management for IBS patients *[22]*. In a cross-sectional study of 3363 adults, coffee consumption was associated with higher risk for IBS, especially in women and in subjects with a BMI lower than 25 kg/m^2 *[23]*. In a study on 330 IBS

patients, coffee was one of the top ten most frequent drinks and a higher intake of coffee was associated with gastrointestinal symptoms. The individuals reported dyspepsia, pain and loose stools as the three most common symptoms after coffee consumption *[24]*. In a community study on 3426 rural Indian population, coffee or tea intake increased the risk of IBS *[25]* and this finding was observed in two previous epidemiologic studies *[26, 27]*. In a randomized controlled trial on IBS patients, restriction of coffee consumption improved the symptoms and decreased IBS severity score *[28]*. Generally, coffee was identified as being the most frequently reported to cause symptoms in people with IBS and to manage these symptoms, the NICE (the National Institute for Health and Care Excellence) guideline proposes limiting the intake of high sources of caffeine such as coffee and tea, and subjects with IBS should not consume more than three cups of tea or coffee per day or 400 mg caffeine *[21]*.

Relaxation of the lower esophageal sphincter (LES) is considered as the main cause of GERD and coffee consumption is one of the GERD-related food triggers, which can induce this mechanism. In a large US-nationwide cohort of women, higher intake of tea, soda and coffee were related to an increased incidence of GERD symptoms, while drinking water instead of tea, coffee or soda decreased the risk of symptoms *[29]*. In a web-survey of 792 students, coffee consumption was a potential risk factor for the presence of GERD *[30]*. Similarly, drinking two cups of tea per day increased the prevalence of GERD in Syrian undergraduate and graduate students *[31]*. Wei et al. have reported that substituting water with soda, coffee or tea reduced the risk of GER symptoms or erosive esophagitis *[32]*. In observational studies, coffee consumption was associated with the induction of symptoms in more than 50% of subjects with FD [33-35]. In a large study in the Chinese population, it was proposed that the regular coffee consumption might be associated with FD *[36]*. Along with coffee, tea intake was associated with aggravated FD symptoms in a cross-sectional study *[34]*.

Coffee consumption may lead to constipation and increase colonic transit time *[37]*. However, in a cross-sectional study of 3835 Japanese women aged 18-20 years, tea and coffee were not associated with functional constipation *[38]*. There was also no association between coffee consumption and dairy products with functional constipation in this population *[39]*. Another study was conducted in 16,840 participants, who were between 45–75 years of age; no correlation was observed between the consumption of caffeinated drinks and functional constipation *[40]*.

Milk and functional gastrointestinal disorders

Lactose is the main disaccharide in milk; it is poorly digested in a large population of adults around the world because of lactase deficiency *[41]*, a β-galactosidase, which is an important enzyme on the apical surface of enterocytes in the small intestine *[42]*. Undigested lactose metabolites including gas (*e.g.*, hydrogen) and short-chain fatty acids can induce luminal distension and stimulate GI symptoms *[43]* like abdominal pain, bloating and loose stool *[41]*. A large number of patients with IBS have reported that milk aggravates their symptoms *[44, 45]*. Some trials have indicated that a lactose-free diet improves symptom in the majority of patients *[28]*. Up to 83% of individuals with IBS-D have reported lactose intolerance. They can tolerate only 10-gr of lactose (equal to one cup of milk) *[46]*.

In a community-based survey of adults, infrequent milk consumption (< 3 times per week) was associated with GERD *[47]*. In a retrospective evaluation of patients with typical reflux symptoms, milk intolerance was determined as a potential risk factor for GERD *[48]*. In contrast, in an analysis of data from the Nurses' Health Study II, the consumption of water, juice or milk was not associated with GERD symptoms *[49]*. In this

regard, a prospective survey demonstrated that drinking coffee with milk was not related to reflux symptoms *[50]*. However, a randomized controlled pilot trial suggested that milk intolerance does trigger symptoms of GERD *[51]*. In this regard, Mwandri et al. reported that sour or fermented milk can aggravate GERD symptoms *[52]*.

In a case-control study, 44% of patients with FD reported dyspeptic symptoms with ingestion of milk compared to 13.3% of the control group *[33]*. In another study, milk was found to be one of the most common food items which increase heartburn and epigastric burning in patient with FD *[35]*. Higher milk consumption cause fullness, bloating, epigastric burning and heartburn in patients with FD. Generally, epidemiological studies demonstrated that triggering symptoms in subjects with FD may be due to intolerance of lactose or fat in milk *[53]*.

Lactose intolerance is a common cause of FGID and FC *[54]*. Food allergy to cow milk protein may be associated with constipation. A crossover dietary trial indicated a direct relation between cow milk consumption and chronic functional constipation *[55]*. In another study, Bae SH, et al. reported that eliminating the cow milk antigen improves constipation symptoms in the majority of infants*[56]*.

Fruit juice and FGID

Fruit juices are drinks with a high content of fructose. Fructose intolerance usually occurs when in diets with high fructose content. In this case, high amounts of fructose are remained unabsorbed in the small intestine and have prebiotic function in the colon. Fruit juices provide a substrate for bacteria fermentation and produce colonic gas formation, osmotic pressure, and cause distension of large intestine and abdominal pain in many IBS patients *[57]*. In a study, females with IBS tolerated lower amounts of fruit juices *[58]*.

Fruit juices intake increases pressure gradient from the abdomen to the chest and GERD symptoms by increasing abdominal pressure or decreasing the lower esophageal sphincter *[59]*.

Feldman et al. suggested that restricting citrus juice may be effective in the management of GERD *[59]*, and avoidance of citrus juice may relieve the symptoms *[60]*. It has been proposed that citrus juice may irritate damaged endothelium in patients with GERD *[61]*. Hence, intake of citrus juice may aggravate GERD symptoms by increased gastric juice secretion, delaying stomach evacuation and reduce LES pressure *[62]*. However, some studies found no association between citrus juice and GERD *[63, 64]*.

Akhondi-Meybodi et al. indicated that citrus exacerbates the symptoms of non-ulcer dyspepsia. It has been reported to intensify the symptoms in 42% of the patients*[34]*. Fruit juices contain fructose, sorbitol, phytochemicals and water. In addition, some juices contain fibers and it can improve constipation, particularly in young children. Pear, prune and apple juices are usually recommended for constipation improvement *[56]*.

Soft drinks and FGIDs

Soft drinks usually contain high amounts of sucrose and fructose (50 g fructose/500–1,000 ml) *[65]*. Reducing the frequency of soft drinks intake is associated with lower IBS severity score, less abdominal pain, less diarrhea and less bloating and flatulence *[66]*. In an epidemiologic study on 3426 rural Indian subjects, aerated soft drink have been suggested as a risk factor for dyspepsia and irritable bowel syndrome *[25]*. In Randomized Controlled Trial, restriction soft drinks consumption was introduced as one of the ingredients of the traditional IBS diet and a lower IBS severity score *[28]*. In a cross-sectional study in 384 patients, soft drinks consumption was associated with aggravation of symptoms *[34]*.

Carbonated soft drinks may decrease the transient lower esophageal sphincter basal pressure and intra-esophageal pH in a short period *[67]*. In a recent survey, more intakes of soft drinks were seen in patients with moderate to severe GERD symptoms

[68]. In another study, soft drinks with higher calorie contributed to the development of GERD *[69]*.

Higher drinking of carbonated beverages is considered as a main dietary factor for severe symptoms of FGIDs due to caffeine and other components present in these beverages. Ligaarden et al. have reported that the consumption of carbonated beverages was high in patients with Diarrhea-IBS *[70]*. This direct association was consistent with the results of one study that indicated a more intake of cola consumption in subjects with IBS compared to controls *[71]*. Moreover, one study reported that individuals with IBS suffer from more gastrointestinal problems when they consume carbonated beverages *[58]*. In a randomized controlled clinical trial, the restriction of carbonated beverage consumption was one of the features of a diet that reduced the IBS severity score *[28]*. In a cross-sectional study in 2018, frequent carbonated drinks (>2 times a week) was significantly related to a diagnosis of GERD *[72]*. This finding agrees with the study results that this beverage reduce the pressure of the lower esophageal sphincter *[73]*. According to a recent Korean study, carbonated drinks causes exacerbation of GERD symptoms *[74]*. In an epidemiological study on young people from Saudi Arabia, carbonated beverages consumption was related to symptomatic GERD *[75]* which was similar to the findings of studies in Iran and Syria *[76, 77]*.

In a comparative study, it was reported that carbonated drinks are the most common symptom triggering food items in functional dyspepsia and also more likely to cause a symptom in postprandial distress syndrome as one subgroups of FD *[78]*. Similarly, in epidemiological studies, carbonated beverages intake were associated with worsening the symptoms in GERD *[33, 34]*. In another study carbonated drinks stimulated the symptoms in 86.7% of the patients with dyspepsia *[34]*.

Water and FGIDs

In a study in 2018 on 4763 patients with IBS, there was a significant and positive association between heavy intra-meal fluid and IBS *[79]* which was in agreement with the findings of a cross-sectional study of 988 adolescent girls *[19]*. In a case-control study, cold water consumption leads to declined visceral perception threshold that was negatively related to the abdominal pain, bloating and diarrhea in symptomatic diarrhea-predominant IBS patients *[80]*. In a pilot study on 27 patients, drinking alkaline-reduced water for eight weeks was reported to increase the quality of life in patients with diarrhea-predominant IBS *[81]*. Intra-meal fluid intake was not significantly related to chronic uninvestigated dyspepsia in a cross-sectional study from Iran *[82]*.

In another cross-sectional study in 4763 adults, intra-meal fluid intake was not related to GERD *[83]*. In a case report it was expressed that frequent sips of water can be used in the management of ineffective motility induced refractory cough and gastroesophageal reflux *[84]*. In a prospective study, drinking water instead of soda, tea or coffee were associated with a decreased risk of GERD *[64]*. When water was consumed with meals, it was emptied quickly from the stomach, and therefore had a low and temporary impact on gastric volume and dilatation.

Epidemiological evidence suggests an association between a low fluid intake and intestinal constipation. Against what may have been thought to be the case, that drinking water improves constipation, many studies, including the 2014 ESPGHAN (the European Society for paediatric Gastro-Enterology, Hepatology, and Nutrition) did not confirm evidence supporting the use of extra fluid intake is helpful for functional constipation *[85]*. Extra fluid during treatment for chronic functional constipation was associated with better bowel movement frequency and stool consistency in children who were used polyethylene glycol *[86]*. However, a moderate increase of water drinking did not improve colorectal function and

constipation symptoms in dehydrated individuals. In a study on 212 children, showed that the intake of 500 mL or less of water was a strong predictor of intestinal constipation in children *[87]*. In another study in 1426 Taiwanese students aged between 10-18 years it was demonstrated that reduced daily intake of fluids was independently related to higher risk of bowel frequency *[88]*. Similarly in a study of 383 schoolchildren aged between 8 and 10 years in Hong Kong, a lower prevalence of intestinal constipation in subjects with fluid intake of at least 3 glasses was observed *[89]*. In randomized, double blind, controlled study indicated that natural mineral water which is rich in sulphate and magnesium improved functional constipation during 7 days *[90]*.

Conclusion

In this study, the association between some frequent fluids such as water, carbonated beverages, soft drinks, milk, caffeinated drinks and fruit juices and the major FGIDs including IBS, GERD, FD and FC were reviewed. Totally, the findings from the previous studies indicated that higher intakes of caffeinated drinks, fruit juice, milk, soft drinks and carbonated beverages were associated with aggravating symptoms in GERD, IBS, and FD. The evidence for the association between water consumption with GERD, IBS, and FD were limited and inconsistent. However, fruit juices and water consumption were related to constipation improvement. To clear these associations, further investigation is recommended for the role of different fluids consumption in FGIDS.

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Authors' contributions

Data extraction was performed by ZF. The paper was drafted by ZF and GAF. MGM supervised the study. All authors contributed to the development of, and read and approved the final version of, the manuscript.

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Conflict of Interest

The authors have no conflict of interest to disclose.

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