LITERATURE REVIEW

Effectiveness of Fiber Supplementation for Constipation, Weight Loss, and Supporting Gastrointestinal Function: A Narrative Review of Meta-Analyses

Marc P. McRae, MSc, DC, FACN, DACBN

ABSTRACT

Objective: The purpose of this narrative review is to determine whether published meta-analyses support the use of fiber supplementation in the treatment of constipation, weight loss, and dietary support for gastrointestinal disorders such as irritable bowel syndrome (IBS) and inflammatory bowel disease.

Methods: A PubMed search from January 1, 1980, to July 31, 2019, was conducted with the following search strategy: (fiber OR fibre) AND (meta-analysis OR systematic review) AND (constipation OR body weight OR obesity OR irritable bowel syndrome OR inflammatory bowel disease). Meta-analyses that provided quantitative statistical analysis with a measured effect size were retrieved and accepted into this review. The following was extracted and entered into an Excel spreadsheet: number of publications included in the meta-analysis, number of total participants, fiber type and daily dose, pooled treatment effects for clinical endpoints, or summary relative risks.

Results: Eighteen meta-analyses support dietary fiber supplementation for patients with constipation, weight loss, and IBS, but the significant heterogeneity and publication bias undermine the support for using dietary fiber supplementation in these conditions.

Conclusion: This narrative review of meta-analyses finds some benefits for recommending fiber supplementation to patients with constipation, obesity, and IBS, but significant heterogeneity and publication bias undermine this support. (J Chiropr Med 2020;19;58-64)

Key Indexing Terms: *Dietary Fiber; Meta-Analysis; Constipation; Irritable Bowel Syndrome; Weight Loss*

INTRODUCTION

Prior reviews suggest that increasing dietary fiber consumption is beneficial for reducing the incidence of cardiovascular disease, type 2 diabetes, and colorectal cancer.[1-3] However, other common reasons a health care practitioner may recommend fiber supplementation is for patients who have constipation[4-6] or gastrointestinal conditions such as irritable bowel syndrome (IBS),[7,8] or to enhance weight loss in patients being treated for obesity.[9] The purpose of this narrative is to determine whether published meta-analyses support the use of fiber supplementation in the treatment of constipation, weight loss, and dietary support for gastrointestinal disorders such as IBS and chronic inflammatory bowel disease.

METHODS

A PubMed and CINAHL search from January 1, 1980, to July 31, 2019, was conducted with the following search strategy: (fiber OR fibre) AND (meta-analysis OR systematic review) AND (constipation OR body weight OR obesity OR irritable bowel syndrome OR inflammatory bowel disease). Abstracts, conference proceedings, and gray literature were not included, as the focus of this review was restricted to peer-reviewed full-length meta-analyses. Meta-analyses that did not present study-specific summary data using a minimum of 3 randomized controlled trials were excluded.

The titles and abstracts from the literature search were scanned, and only English-language meta-analyses that provided quantitative statistical analysis with a measured effect size were retrieved and accepted into this review. For

Department of Basic Sciences, National University of Health Sciences.

Corresponding author: Marc P. McRae, MSc, DC, FACN, DACBN, NUHS 200 E. Roosevelt Road, Lombard, IL 40148. (e-mail: *mmcrae@nuhs.edu*).

Paper submitted February 8, 2019; in revised form August 7, 2019; accepted October 10, 2019.

1556-3707

https://doi.org/10.1016/j.jcm.2019.10.008

the published papers that were accepted into this review, the following information was extracted and entered into an Excel spreadsheet: number of publications included in the meta-analysis, number of total participants, fiber type and daily dose, pooled treatment effects for clinical endpoints, or summary relative risks. Although these items were not always present, the meta-analyses were also analyzed for their disclosure of quality assessment, statistical heterogeneity (Cochrane's Q test and I^2 statistic), and publication bias (visual inspection of funnel plots and Egger or Begg regression test).

Because this is a narrative summary review of meta-analyses, no statistical analyses were performed.

Results

The initial search strategy identified 43 articles, and after careful review, 18 meta-analyses were retrieved for inclusion into this narrative review.[10-27] The 18 meta-analyses are presented in Tables 1 through 4.

Analysis of the findings is presented under the following 4 categories: constipation, body weight loss, IBS, and inflammatory bowel disease.

Constipation

Constipation affects up to 20% of the adult population in North America and negatively affects the quality of life and increases the risk of developing colorectal cancer.[28] Symptoms include fewer than 3 bowels movements a week, incomplete sensation of evacuation, increased stool hardness, abdominal distention, and pain.[29]

Both dietary and functional fiber supplementation may be recommended for these patients.[4-6] Water-insoluble, nonfermentable fibers directly increase luminal bulk, resulting in decreased gut transit time to promote laxation, and water-soluble fibers have a high water-holding capacity leading to bulky/soft stools that are easy to pass.[30] Fermentable fibers may promote laxation, as they can increase stool bulk and weight by increasing microbial biomass growth; however, clinical trials show that fermentable fibers have no effect on stool output or stool softening, thereby challenging the concept that increasing microbial biomass provides a regulatory benefit.[31]

Two separate meta-analyses have shown a significant increase in stool frequency when fiber supplementation was compared with placebo.[10,11] Concerning stool consistency, fiber supplementation significantly softened stool consistency compared with placebo for 1 meta-analysis but

Table 1. *Effects of Fiber Supplementation on Global Improvement in Constipation and Hemorrhoids*

Meta-analysis	Number of Studies in Analysis	Number of Participants in Analysis	Fiber Dose (average amount per day)	Mean Duration (wk)	Global Improvement in Gastrointestinal Function	Q Test P Value	I^2 (%)
Yang et al 2012[10]	5	195	7 g	4	Stool frequency OR = 1.19, $P < .05$ Stool consistency OR = 0.43, NS	NS .01	0 75
Christodoulides et al 2016[11]	4	287	15 g	3	Stool frequency SMD = 0.39, $P = .03$ Stool consistency SMD = 0.35, $P = .02$	.04 NS	56 34
Yurrita et al 2014[12]	5	252	5 g Inulin	3	Stool frequency SMD = 0.69, $P < .05$ Stool consistency SMD = 1.07, $P < .05$	.000 NS	ND ND
Han et al 2017[13]	4	287	15 g Glucomannan	4	Stool frequency SMD = 1.40, $P = .008$ Stool consistency SMD = 0.48, NS	NS .009	53 79
De Vries et al 2019[14]	25	1495	10 g β-Fructans	3	Stool frequency SMD = 0.28, $P < .001$ Stool consistency SMD = 0.23, $P < .01$	.000 ND	83 ND
Alonso-Coello et al 2006[15]	5	295	15 g	6	Hemorrhoid symptoms RR = 0.53, $P < .05$ Bleeding RR = 0.50, $P < .05$	NS NS	0 45

ND, not disclosed; *NS*, not significant; *OR*, odds ratio; *RR*, risk ratio; *SMD*, standardized mean difference.

Table 2. *Effects of Fiber Supplementation on Weight Loss*

Meta-analysis	Number of Studies in Analysis	Number of Participants in Analysis	Fiber Type and Average Dose per Day	Mean Duration of Studies (wk)	Weight Loss (kg) *P* Value	Q Test *P* Value	I^2 (%)
Thompson et al 2017[16]	10	520	Fiber, 16 g	10	2.52, $P = .004$	.0001	96
Mhurchu et al 2005[17]	13	1071	Chitosan, 4 g	7	1.7, $P < .0001$	.0003	73
Sood et al 2008[18]	9	250	Glucomannan, 5 g	6	0.8, $P < .05$	ND	ND
Onakpoya et al 2014[19]	8	301	Glucomannan, 3 g	7	0.2, NS	.006	65
Pittler and Ernst 2001[20]	11	395	Guar gum, 15 g	10	0.04, NS	ND	ND

ND, not disclosed; *NS*, not significant.

Table 3. *Effects of Fiber Supplementation on Global Improvement in IBS Symptoms*

Meta-Analysis	Number of Studies in Analysis	Number of Participants in Analysis	Fiber Dose (average amount per day)	Mean Duration (wk)	Global Improvement in IBS Symptoms, *P* Value	Q Test *P* Value	I^2(%)
Bijkerk et al 2004[21]	12	1025	15g	8	RR = 1.33, $P < .0001$	$P = .003$	ND
Ford et al 2008[22]	12	591	15g	9	RR = 0.87, $P < .05$	NS	14
Ruepert et al 2011[23]	11	565	15g	9	RR = 1.10, NS	NS	0
Moayyedi et al 2014[24]	14	999	ND	9	RR = 0.86, $P = .0005$	NS	0
Nagarajan et al 2015[25]	15	1218	19g	8	RR = 1.27, $P = .01$	$P = .03$	43

IBS, irritable bowel syndrome; *ND*, not disclosed; *NS*, not significant; *RR*, risk ratio

Table 4. *Effects of Dietary Fiber Intake on Inflammatory Bowel Disease and Circulating CRP*

Meta-analysis	Number of studies in analysis	Number of participants in analysis	Outcome and *P* Value	Q Test *P* Value	I^2(%)
Liu et al 2015[26]	8	1806	Relative risk of Crohn disease = 0.44, $P = 00$ Relative risk of ulcerative colitis = 0.80, NS	.034 NS	56 48
Jiao et al 2015[27]	14	728	Circulating CRP WMD = 0.37 mg/L, $P = .05$	NS	4

CRP, C-reactive protein; *WMD*, weighted mean difference.

not the other. The findings of significant heterogeneity (inconsistent effects) between these studies in one of each of the stool frequency and stool consistency observations could be due to the use of 5 different dietary fibers types being used by different studies (psyllium, inulin, β-glucan, glucomannan, and resistant maltodextrin). The physiochemical characteristics of these fiber types are diverse, and therefore it is challenging to select which fiber supplementation should be used in patients with constipation using these 2 studies. The authors of the second meta-analysis concluded that fiber supplementation is moderately effective, but the overall quality of the evidence was low.[11]

In the 2 meta-analyses concentrating only on trials using either inulin or β-fructans, a significant increase in stool frequency and consistency (with a reduction of hardness in stool) was observed compared with placebo.[12,14] However, significant heterogeneity was observed in both meta-analyses, and significant publication bias was observed in the meta-analysis using inulin studies. Finally, in a meta-analysis of glucomannan supplementation studies on functional constipation in children, a significant increase in stool frequency was observed; however, there were no significant differences in the outcomes of stool consistency.[13]

If fiber supplementation can alleviate constipation and straining that goes along with constipation, fiber supplementation may help reduce the incidence of developing hemorrhoids, which typically affect between 4% and 5% of the adult North American population.[32] The only meta-analysis on this topic found that the pooled analysis for overall improvement showed a 47% reduction in the risk of persistent symptomatic hemorrhoids, and a 50% reduction in reported bleeding compared to placebo.[15] Although there was no significant heterogeneity, significant publication bias was observed, and therefore the observed results may represent an overestimate of the true underlying treatment effect.

Body Weight Loss

Health care practitioners may suggest dietary or functional fiber supplementation for losing weight.[9] Dietary and functional fibers increase the volume of food while reducing the metabolizable energy density of the food and therefore decrease the patient's total energy intake. Soluble fibers can slow gastric emptying and delay or decrease nutrient absorption of fats and glucose, thereby reducing both caloric uptake and pancreatic insulin secretion.[30]

Because soluble fibers can hold large quantities of water, they can increase stomach distension that may trigger afferent vagal signals of fullness, leading to satiation.[30] Also, the short-chain fatty acid products of fermentable dietary fibers can increase satiety by stimulating G protein-coupled receptors on the membrane of colonocytes, thereby promoting the secretion of appetite-suppressing peptides such as cholecystokinin, peptide YY, and glucagon-like peptide 1.[30] However, functional fibers do not induce satiety or food intake.[33,34] One review found that only 39% of the treatments were significant for satiety and only 22% were significant for food intake.[33]

In a meta-analysis on studies using various fiber types, a significant reduction in body weight of 5.5 pounds was observed.[16] However, there was significant heterogeneity in this meta-analysis that used 9 different fiber supplement types: flaxseed mucilage, fructooligosaccharide, galactomannan, soluble dextrin, galactooligosaccharide, oligofructose, glucomannan, mannooligosaccharide, and pectin. The physiochemical characteristics of these 9 fiber types are very different, and therefore the efficacy attributed to any one particular fiber type used in this meta-analysis is uncertain.

A meta-analysis of chitosan supplementation showed a significant reduction in body weight loss of almost 4 pounds.[17] However, significant heterogeneity was observed. Chitosan is the deacetylated form of chitin, which is derived from the shells of crustaceans, and is a water-soluble functional fiber that can effectively chelate luminal free fatty acids, thereby reducing their absorption and promoting their fecal excretion. This effectively reduces total caloric intake derived from dietary free fatty acids.

In a meta-analysis of studies using glucomannan supplementation, a significant body weight loss of 1.7 pounds was calculated.[18] However, a second meta-analysis using a slightly longer treatment duration found a nonsignificant loss of body weight of only 0.5 pounds.[19] There were 5 shared studies between these 2 meta-analyses. The authors of the second meta-analysis concluded that their finding "does not show that glucomannan intake generates statistically significant weight loss."[19]

In a meta-analysis of studies using guar gum supplementation, no appreciable weight loss was observed. The authors concluded that the risks of taking guar gum (flatulence, diarrhea, abdominal pain, and cramps) outweighed the benefits.[20]

Irritable Bowel Syndrome

Irritable bowel syndrome is a functional gastrointestinal disorder characterized by recurrent episodes of abdominal pain and accompanied by disturbed changes in bowel habits. Irritable bowel syndrome affects 9% to 27% of the adult North American population, and fiber supplementation is commonly recommended as a nonpharmacologic treatment to as many as 88% of all IBS patients.[28,35-37]

Insoluble fiber undergoes minimal changes in the digestive tract and shortens colonic transit time, causing an increase in the fecal mass. The shortened transit time may alleviate constipation and decrease intracolonic pressure, resulting in a reduction in pain. Fermentable fibers produce short-chain fatty acids that provide energy for colonocytes, act as anti-inflammatory agents, provide substrates for gut bacteria, and promote a healthy gut microbiome that promotes a healthy functional gastrointestinal tract.[30]

There are currently 5 meta-analyses investigating the efficacy of fiber supplementation for treating patients with IBS.[21-25] Using the Global Assessment of IBS Symptoms evaluation, 4 of the 5 meta-analyses showed significant clinical improvements with fiber supplementation. Using the latest published meta-analysis, the proportion of patients with IBS reporting clinical relief improved significantly by $1.27\times$.[25] Two types of fiber, soluble and insoluble, affected IBS symptoms differently. Soluble fiber was beneficial to Global Assessment of IBS Symptoms, as Global Assessment of IBS Symptoms was improved by $1.49\times$, whereas insoluble fiber was not more effective than placebo, and some IBS patients they reported worse symptoms, including more pain, compared with the placebo group. The authors concluded that IBS patients should include soluble fiber supplements in their diet and not insoluble fiber.[25]

Inflammatory Bowel Disease

Compared with IBS, the incidence of both Crohn disease and ulcerative colitis in the United States is less common with an average incidence rate of 0.4% to 0.6%.[38] A

study has shown that dietary fiber reduces the risk of both inflammatory bowel diseases.[26] When comparing the highest vs lowest categories of dietary fiber intake, there was a significant reduction in the incidence of Crohn disease by 56% and a nonsignificant reduction in the incidence of ulcerative colitis by 20%. However, significant heterogeneity was observed in the Crohn disease meta-analysis. A linear dose-response relationship was found between dietary fiber and Crohn disease where the incidence decreased by 13% for every 10 g/d increment in dietary fiber.[26] Dietary fiber is proposed to have an anti-inflammatory effect via the fermentable fiber's short-chain fatty acid product butyrate, which downregulates the transcription factor NF-κB. A meta-analysis supporting this anti-inflammatory effect showed that dietary fiber supplementation in overweight or obese adults had a slight but significant reduction of C-reactive protein levels.[27]

Discussion

Based on this review, physicians should continue recommending dietary or functional fibers for patients with IBS, but the fiber supplements should only be of the water-soluble type such as psyllium or β-glucan. For constipation, dietary and functional fiber supplementation promotes significant increases in stool frequency and a reduction of persistent hemorrhoid symptoms. However, these studies have problems with heterogeneity and publication bias, and this undermines the support of the findings. Heterogeneity may include the different physiochemical properties of the various fibers, different fiber dosages and treatment durations, and differing participant characteristics. Finally, regarding body weight reduction, not all fiber types appear to be beneficial for promoting weight loss, such as glucomannan and guar gum. The different physiochemical characteristics of the fiber supplements used in these meta-analyses make us question the results of these combined fiber studies. Given the wide variability in fiber's physiochemical properties, it is not surprising that combining different fiber types failed to demonstrate consistent benefits in either constipation or weight management. Meta-analyses published in the future should be encouraged to focus on clinical trials using a single fiber type, such as psyllium, β-glucan, inulin, or chitosan, if enough well-designed trials are available.

Fiber supplementation causes moderate gastrointestinal side effects, such as flatulence, bloating, diarrhea, and abdominal discomfort, which were significantly higher with fiber supplementation compared to placebo.[11,15,25] Soluble fiber supplements such as psyllium and glucomannan are recommended to be consumed with at least 8 ounces of water or other fluids to reduce the possibility of becoming a choking hazard.[13,18]

Three previous reviews of meta-analyses have shown that dietary fiber is beneficial for reducing the incidence of cardiovascular disease, type 2 diabetes, and colorectal cancer.[1-3] Health care practitioners should continue to recommend that their patients eat high-fiber foods such as fruits, vegetables, whole grains, and nuts or maybe supplement their diet with functional fibers such as psyllium, β-glucan, or chitosan. This is especially pertinent as the mean dietary fiber intake by adults in the United States is currently only 17 g/d, which is clearly under the recommendation of 14 g/1000 kcal or 25 to 38 g/d as recommended by the National Academy of Medicine.[39]

Limitations and Recommended Studies

This narrative review had several limitations that should be acknowledged. First, the quality of this narrative review is directly related to the quality of the included meta-analyses, which are dependent upon the design and reporting quality of the individual meta-analysis itself and on the quality of the individual studies used to conduct the meta-analysis. Second, confounding factors are always a potential threat to the validity of any meta-analysis. For instance, people who consume high dietary fiber intakes tend to have other healthy behaviors, such as being more physically active, lower dietary intakes of saturated fat and processed meats, and avoiding smoking and excessive alcohol intake. Additional research is needed, which should include large, well-designed randomized controlled studies to identify specific types of fibers and doses regarding clinical endpoints such as constipation, weight loss, or the symptoms of IBS. Larger studies following patients for longer durations of time are also needed.

Conclusion

This narrative review of meta-analyses found some benefits for recommending fiber supplementation to patients with constipation, obesity, and IBS, but significant heterogeneity and publication bias undermined this support.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): M.P.M.
Design (planned the methods to generate the results): M.P.M.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): M.P.M.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.P.M.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): M.P.M.
Literature search (performed the literature search): M.P.M.
Writing (responsible for writing a substantive part of the manuscript): M.P.M.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.P.M.

Practical Applications:

- Although previous umbrella reviews have shown that dietary fiber consumption is beneficial for reducing the incidence of cardiovascular disease, type 2 diabetes and colorectal cancer, this mini-review illustrates that we must not forget that the most common reason a healthcare practitioner may recommend fiber supplementation is for patients suffering from constipation, irritable bowel syndrome or to enhance weight loss in patients being treated for obesity.

References

1. McRae MP. Dietary fiber is beneficial for the prevention of cardiovascular disease: an umbrella review of meta-analyses. *J Chiropr Med*. 2017;16(4):289-299.
2. McRae MP. Dietary fiber intake and type 2 diabetes mellitus: an umbrella review of meta-analyses. *J Chiropr Med*. 2018;17(1):44-53.
3. McRae MP. The benefits of dietary fiber intake on reducing the risk of cancer: an umbrella review of meta-analyses. *J Chiropr Med*. 2018;17(2):90-96.
4. Soffer EE. Constipation: an approach to diagnosis, treatment, referral. *Cleve Clin J Med*. 1999;66(1):41-46.
5. Schiller LR. New and emerging treatment options for chronic constipation. *Rev Gastroenterol Disord*. 2004;4(suppl 2): S43-S51.
6. Hsieh C. Treatment of constipation in older adults. *Am Fam Physician*. 2005;72(11):2277-2284.
7. Hadley SK, Gaarder SM. Treatment of irritable bowel syndrome. *Am Fam Physician*. 2005;72(12). 2501-256.
8. Basnayake C. Treatment of irritable bowel syndrome. *Aust Prescr*. 2018;41(5):145-149.
9. Alfieri MA, Pomerleau J, Grace DM, Anderson L. Fiber intake of normal weight, moderately obese and severely obese subjects. *Obes Res*. 1995;3(6):541-547.
10. Yang J, Wang HP, Zhou L, Xu CF. Effect of dietary fiber on constipation: a meta analysis. *World J Gastroenterol*. 2012;18(48):7378-7383.
11. Christodoulides S, Dimidi E, Fragkos KC, Farmer AD, Whelan K, Scott SM. Systematic review with meta analysis: effect of fibre supplementation on chronic idiopathic constipation in adults. *Aliment Pharmacol Ther*. 2016;44(2):103-116.
12. Yurrita LC, Martín ISM, Ciudad-Cabañas MJ, Calle-Purón ME, Cabria MH. Effectiveness of inulin intake on indicators of chronic constipation; a meta-analysis of controlled randomized clinical trials. *Nutr Hosp*. 2014;30(2):244-252.
13. Han Y, Zhang L, Liu XQ, Zhao ZJ, Lv LX. Effect of glucomannan on functional constipation in children: a systematic review and meta-analysis of randomized controlled trials. *Asia Pac J Clin Nutr*. 2017;26(3):471-477.
14. De Vries J, Le Bourgot C, Calame W, Respondek F. Effects of β-fructans fiber on bowel function: a systematic review and meta-analysis. *Nutrients*. 2019;11(1).
15. Alonso-Coello P, Mills E, Heels-Ansdell D, et al. Fiber for the treatment of hemorrhoids complications: a systematic review and meta-analysis. *Am J Gastroenterol*. 2006;101(1):181-188.
16. Thompson SV, Hannon BA, An R, Holscher HD. Effects of isolated soluble fiber supplementation on body weight, glycemia, and insulinemia in adults with overweight and obesity: a systematic review and meta-analysis of randomized controlled trials. *Am J Clin Nutr*. 2017;106(6):1514-1528.
17. Mhurchu CN, Dunshea-Mooij C, Bennett D, Rodgers A. Effect of chitosan on weight loss in overweight and obese individuals: a systematic review of randomized controlled trials. *Obes Rev*. 2005;6(1):35-42.
18. Sood N, Baker WL, Coleman CI. Effect of glucomannan on plasma lipid and glucose concentrations, body weight, and blood pressure: systematic review and meta-analysis. *Am J Clin Nutr*. 2008;88(4):1167-1175.
19. Onakpoya I, Posadzki P, Ernst E. The efficacy of glucomannan supplementation in overweight and obesity: a systematic review and meta-analysis of randomized clinical trials. *J Am Coll Nutr*. 2014;33(1):70-78.
20. Pittler MH, Ernst E. Guar gum for body weight reduction: meta-analysis of randomized trials. *Am J Med*. 2001;110 (9):724-730.
21. Bijkerk CJ, Muris JW, Knottnerus JA, Hoes AW, de Wit NJ. Systematic review: the role of different types of fibre in the treatment of irritable bowel syndrome. *Aliment Pharmacol Ther*. 2004;19(3):245-251.
22. Ford AC, Talley NJ, Spiegel BM, et al. Effect of fibre, antispasmodics, and peppermint oil in the treatment of irritable bowel syndrome: systematic review and meta-analysis. *BMJ*. 2008;337:a2313.
23. Ruepert L, Quartero AO, de Wit NJ, van der Heijden GJ, Rubin G, Muris JW. Bulking agents, antispasmodics and antidepressants for the treatment of irritable bowel syndrome. *Cochrane Database Syst Rev*. 2011(8) CD003460.
24. Moayyedi P, Quigley EM, Lacy BE, et al. The effect of fiber supplementation on irritable bowel syndrome: a systematic review and meta-analysis. *Am J Gastroenterol*. 2014;109 (9):1367-1374.
25. Nagarajan N, Morden A, Bischof D, et al. The role of fiber supplementation in the treatment of irritable bowel syndrome: a systematic review and meta-analysis. *Eur J Gastroenterol Hepatol*. 2015;27(9):1002-1010.
26. Liu X, Wu Y, Li F, Zhang D. Dietary fiber intake reduces risk of inflammatory bowel disease: result from a meta-analysis. *Nutr Res*. 2015;35(9):753-758.
27. Jiao J, Xu JY, Zhang W, Han S, Qin LQ. Effect of dietary fiber on circulating C-reactive protein in overweight and obese adults: a meta-analysis of randomized controlled trials. *Int J Food Sci Nutr*. 2015;66(1):114-119.
28. Harris LA, Hansel S, DiBaise J, Crowell MD. Irritable bowel syndrome and chronic constipation: emerging drugs, devices, and surgical treatments. *Curr Gastroenterol Rep*. 2006;8 (4):282-290.

29. Sanchez MI, Bercik P. Epidemiology and burden of chronic constipation. *Can J Gastroenterol*. 2011;25(suppl B):11B-15B.
30. Slavin J. Fiber and prebiotics: mechanisms and health benefits. *Nutrients*. 2013;5(4):1417-1435.
31. McRorie JW, McKeown NM. Understanding the physics of functional fibers in the gastrointestinal tract: an evidence-based approach to resolving enduring misconceptions about insoluble and soluble fiber. *J Acad Nutr Diet*. 2017;117(2):251-264.
32. Lohsiriwat V. Hemorrhoids: from basic pathophysiology to clinical management. *World J Gastroenterol*. 2012;18(17):2009-2017.
33. Clark MJ, Slavin JL. The effect of fiber on satiety and food intake: a systematic review. *J Am Coll Nutr*. 2013;32(3):200-211.
34. Warrilow A, Mellor D, McKune A, Pumpa K. Dietary fat, fibre, satiation, and satiety—a systematic review of acute studies. *Eur J Clin Nutr*. 2019;73(3):333-334.
35. Saha L. Irritable bowel syndrome: pathogenesis, diagnosis, treatment, and evidence-based medicine. *World J Gastroenterol*. 2014;20(22). 6759-6573.
36. Enck P, Aziz Q, Barbara G, et al. Irritable bowel syndrome. *Nat Rev Dis Primers*. 2016;2:16014.
37. Thompson WG, Heaton KW, Smyth GT, Smyth C. Irritable bowel syndrome: the view from general practice. *Eur J Gastroenterol Hepatol*. 1997;9(7):689-692.
38. Loftus EV. Update on the incidence and prevalence of inflammatory bowel disease in the United States. *Gastroenterol Hepatol (N Y)*. 2016;12(11):704-707.
39. McGill CR, Birkett A, Fulgonii III VL. Healthy Eating Index-2010 and food groups consumed by US adults who meet or exceed fiber intake recommendations NHANES 2001−2010. *Food Nutr Res*. 2016;60:29977.