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Review Article

Diabetes Mellitus, Constipation, and Fiber Intake

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Abstract

Dietary fiber is a term that includes the edible parts of plants or analogous carbohydrates resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Functional fibers are isolated, non-digestible carbohydrates which have beneficial physiological effects in humans. Total fiber is the sum of dietary and functional fiber. Dietary fiber is important for human beings because it is associated with a normal gut microbiota. Gut microbes act upon dietary fiber to produce metabolites like short-chain fatty acids, which may be absorbed into the circulation and are thought to affect metabolic regulation processes. These fatty acids may also be a substrate for other gut microbes.

Although increasing dietary fiber intake is a general recommendation for overall health as well as for constipation, there is a 30-year debate and strong controversy about the scientific evidence of its clinical benefits and about the type and amount of fiber to be prescribed in each case. This document analyzes the evidence about the types and mechanism of action of dietary fiber for managing constipation. We propose an algorithm of steps clinicians must have in mind when prescribing fiber supplements for people with type 2 diabetes mellitus with constipation.

Keywords: Dietary Fiber Intake; Constipation; Type 2 Diabetes Mellitus; Treatment Algorithm

Constipation and type 2 diabetes mellitus

Regular bowel movements are defined as the daily elimination of bulky, soft, and easy to pass stools. Normal bowel frequency is considered at least three bowel movements per week up to three per day. Constipation is defined as less than three bowel movements per week or elimination of hard or small stools, that are difficult to pass. Stool consistency is related to stool water content.

Constipation is a relatively common functional gastrointestinal disorder, affecting around 30% of the general population, especially women and the elderly. Besides affecting the patient's quality of life, constipation has been associated with increased risk of cardiovascular disease. Recent studies suggest it may also be a risk factor for the development of chronic kidney diseas [1]. Thus, managing constipation in people with diabetes in the early course of the clinical symptoms may help decrease related health risks in this population.

The general recommendations for treating constipation include to increase water and fiber intake, to do more exercise or to be physically active. In this document we will analyze what are dietary fibers, how can they help in the treatment of constipation and several controversies on specific types of dietary fibers. Finally, we will propose a management algorithm for indicating dietary fiber for people with type 2 diabetes and constipation.

What is dietary fiber

Dietary fiber is the part of plant material in the diet that is resistant to enzymatic digestion. American Association of Cereal Chemists in 2000 defined dietary fiber as the edible parts of plants or

analogous carbohydrates resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Functional fibers are isolated, non-digestible carbohydrates which have beneficial physiological effects in humans and total fiber as the sum of dietary and functional fiber.

Dietary fibers can be classified as polysaccharides with a minimum of 10 monomeric unites (MU) or oligosaccharides with 3-9 MU.

Polysaccharides are divided in

- Non-starch polysaccharides (NSP)
- Resistant starch (RS)

Oligosaccharides include Resistant Oligosaccharides (RO). RO are not soluble and viscous, and only partly fermentable [2].

Dietary fibers can also be classified depending on its water solubility, viscosity, and degree of fermentation in the colon.

Water insoluble and less fermented fibers include

- Cellulose (sources are plants such as vegetables and brans), (NSP)
- Hemicellulose (sources are cereal grains) (NSP)
- Lignin, which comes from woody plants and resists bacterial degradation.
- Methylcellulose is a viscous, semisynthetic, chemically treated wood pulp, which is not fermented in the gastrointestinal tract.

Stool water content is directly related to stool consistency. So, fibers that are water soluble and gel-forming can help to improve stool consistency.

Water soluble and well fermented fibers include

- Non-viscous soluble fermentable fibers, also called prebiotics or functional fibers, are inulin, fructooligosaccharide and wheat dextrin. Prebiotics are non-digestible food ingredients, thought to stimulate bifidogenic and lactic acid bacteria in the gastrointestinal tract [3]. Fibers are not digested until they reach the colon. There, they are fermented by the normal microbiota [4]. Inulin and fructans can be classified as non-starch polysaccharides (NSP), while fructooligosaccharides (FOS), galactooligosaccharides (GOS), resistant dextrins and polydextrose are classified as resistant oligosaccharides (RO [2].
- High viscosity, gel forming b-glucans. (It is important to note than b-glucans are contained in oats. Their viscosity depends on their degree of processing (the more processing, the les viscosity). The more viscosity, the more reduction in cholesterol levels (this is true for b-glucans and psyllium only, but not for all b-glucans and not for all doses [5].
- Pectin (which comes from fruits, vegetables, legumes/beans, sugar beet and potatoes) (NSP).
- Gums (proceeding form leguminous seed plants, such as raw guar or locust beans; seaweed extracts like carrageenan or aliginates and microbial gums such as xanthan and gellan).
- And mucilages, which are plant extracts that prevent seed dissecation and are used by de food industry for their hydrophilic properties (acacia, karaya, tragacanth). Psyllium plantago also belongs to this group of mucilages, but contrary to the rest of the group, it is not fermented in the human gut [5].

Dietary fiber recommendations and controversies

The Dietary Guidelines for Americans 2020 - 2025 has a general fiber intake recommendation of 14g/1,000 Kcal consumed per day, or 25 g/d for adult women and 38g/d for adult men. The report states that, in the United States, more than 90% of women and 97% of men don´t meet the recommended intakes of dietary fiber, because there is underconsumption of fruits, vegetables and whole grains in more than 85% of adults in that country [6].

This general recommendation is based on epidemiologic studies that show fiber is protective against cardiovascular disease. Note than the Dietary Reference Intakes for fiber are based on recommended energy intake, not on clinical fiber studies. Despite de recommendations, in 2008 the average dietary fiber intake in the United States was only 15 g/day [7].

Over the last decades the Dietary Guidelines for Americans have generated controversy, because the reports do not provide enough evidence to conclude that increases in whole grain and fiber (or decreases in dietary saturated fat, salt, and animal protein) will lead to positive health outcomes [8].

This controversy was fueled in 2017 by the PURE (Prospective Urban Rural Epidemiology) prospective cohort study. This study analyzed the relationship between macronutrients and cardiovascular disease and mortality, since the evidence its controversial evidence comes from European and North American data, and its applicability to other populations is unclear [9]. The PURE studies concluded that a high carbohydrate intake (more than about 60% of energy from carbohydrates) was associated with a higher risk of total mortality [9].

Despite several dietary guidelines recommend consuming five or more (5 to 9) servings per day of fruits, vegetables, and legumes, the PURE study reported that a "high" fruit, vegetable, and legume consumption was associated with a lower risk of non-cardiovascular and total mortality.

Benefits appear to be maximum at three or four servings per day (375-500g/day) [10], which is much lower than the usual clinical recommendation. On average, 100 grams of fruits, vegetables, and legumes have about 5 g. of fiber. So, the dietary intake considered best in these studies would be around 18 -25 grams of fiber/day. Notice that it is very hard to have a higher fiber intake in a dietary pattern with less than 60% of daily energy from carbohydrates.

Another important issue in dietary fiber intake is the specific world region for the recommendation. The ELANS Study (The Latin American Study of Nutrition and Health) [11] assessed food consumption from an urban sample in 8 Latin American countries. They found that only 7.2% of the sample reached the WHO recommendation of fruits and vegetables (400g/d).

On the other hand, in most Latin American countries the consumption of legumes/beans was about 100-150 g/d. Legumes/beans were highly consumed in costa Rica by 87% of the sample. The vegetable consumption in the ELANS sample was higher than that of fruits.

These data seem to indicate that Latin American fiber intake may be much higher than in the United States. So, before recommending a higher fiber intake in this world region, it is necessary to analyze the patient's current amount and type of fiber intake.

If the patient has clinical findings or is taking medications that may slow intestinal transit, or has irritable bowel syndrome, it is probable that reducing (instead of increasing) fiber intake, or moderating carbohydrate consumption, may help reduce the constipation symptoms.

How can fiber intake help prevent or treat constipation?

For fiber to act as a laxative there are two prerequisites

First, fiber must be present in stool. This means fiber cannot be absorbed, it must remain intact throughout the colon and resist fermentation.

The second prerequisite for fiber to have a laxative effect is that fiber must have significant water holding capacity in the colon to increase stool water content, which is inversely proportional to stool viscosity [5].

Then, there are two mechanisms by which fiber provides a laxative effect:

- By mechanically irritating the colonic mucosa. Large insoluble fiber particles (such as wheat bran) stimulate the secretion of water and mucus. This causes mechanic and irritating diarrhea. Fibers that cause a laxative effect with this mechanism do not retain water, are soluble but not viscous.

- By increasing stool water content. This can be done mainly by soluble gel-forming fiber, that resists dehydration in the colon. To resist dehydration, fiber must resist fermentation (5). Interestingly, clinical trials do not support increased fluid intake to treat functional constipation (12).

Controversies on fermentable fibers

Dietary fibers are not miracle food. Not all fibers are useful for every clinical problem. They have physical and chemical properties that account for their clinical actions.

For example, some high viscosity, gel forming fibers (such as high molecular weight, non-processed b-glucan, and psyllium) will trap cholesterol in the duodenum, so that it is not reabsorbed before it passes to the colon, where cholesterol cannot be absorbed. But since b-glucans can be absorbed along all the small intestine and are fermented in the colon, oats do not have a laxative effect [5].

In the group of viscous, gel-forming and water holding fibers, psyllium plantago deserves a special mention. Psyllium belongs to

this group of fibers, with the important difference that it is not fermented in the colon, so it keeps its viscous properties for improving cholesterol and postprandial glucose levels, and its water retaining properties, which implies it has an effective laxative effect [5].

Guar gum is a viscous, water holding fiber that is readily fermented. Raw guar gum is used to thicken food and beverages. Guar gum is partially hydrolyzed for commercial food preparation because it forms a tight, unpalatable gel when hydrated. But the degree of processing reduces its viscosity. So, processed guar gum does not have the clinical benefits of viscous, gel-forming fibers, nor a laxative effect [5].

We conclude that, due to the likely constipating effects of hydrolyzed guar gum, before treating constipation, patients must reduce the amount of this food additive, which may be present in whole grain breads, beverages as prepared coffees of juice drinks, ice creams and diverse kinds of sauces.

Another group of water soluble, fermentable fibers are non-starch polysaccharides (NSP), which include inulin, fructans and pectin. In theory, fermentable fibers would increase the mass of colonic bacteria and increase stool output. But in well controlled randomized clinical trials, it has been demonstrated that soluble, non-viscous, fermentable fibers (inulin, FOS, and wheat dextrin have been shown not to have a laxative effect. Wheat dextrin and fine/smooth insoluble wheat bran particles can be constipating [5].

Pectin, which is the main dietary fiber in legumes and beans, consumed in large amounts can cause bloating or abdominal pain. Again, before starting a dietary fiber supplement, make sure the amount of pectin in the patient's diet does not exceed the current fiber recommendations. If the constipated patient has abdominal pain, gases, or bloating, decrease the amount of beans in the diet before adding a dietary fiber supplement.

Is wheat bran a treatment option for constipation?

Coarse particles of wheat bran (as well as coarse plastic particles) have been demonstrated to have a laxative effect, because they are not fermented and remain intact throughout the colon (prerequisite #1) Bran has no water holding of gel forming capacity (prerequisite #2) [5]. Its laxative effect is due to mechanical irritation of the colonic mucosa, which stimulates water and mucus secretion. On the contrary, fine/smooth bran particles add to the dry mass of stool and decrease their water content, which leads to a constipating effect [5].

Bran has been reported to cause exacerbation of bowel symptoms, abdominal distension, and pain, it has been suggested that excessive bran consumption may precipitate irritable bowel syndrome, exacerbating mild or non-complaining cases [13].

The current recommendation for irritable bowel syndrome is to have a low FODMAP (fructans, oligosaccharides, disaccharides, monosaccharides, and polyols) diet and a recommendation of less than 20g/d of fiber if there is constipation since fiber may be associated with symptom aggravation in some cases [14].

As a clinician, when you analyze the laxative effect of bran, you must consider if there are better treatment options, that avoid irritation of the colonic mucosa. Since there are better treatment options, bran and its mucosal irritation should be avoided in constipation treatment.

Do prebiotics have a laxative effect?

Consumption of fermentable fiber can change the amounts of specific colonic bacteria. Fermentation in the colon alters the gel forming properties of fibers, thus making them available for dehydration.

So, contrary to popular thought, inulin, oligofructose and fructooligosaccharides don´t comply with the two prerequisites of substances having a laxative effect (remaining intact, without fermentation throughout the colon and keeping their gel-forming, water retaining properties).

Theoretically, fermentable fibers are expected to increase stool output. Nevertheless, scientific studies have failed to demonstrate a laxative effect (increase in stool output, stool softening, nor bowel movement frequency) of non-viscous soluble fermentable fibers, when compared to placebo.

The clinical trials that demonstrated an increase in bowel movement frequency were associated with harder and smaller stool, which is clearly not a health benefit. Wheat dextrin, also a nonviscous fermentable prebiotic, has been shown to have a constipating effect [5].

The positive effects reported for inulin might be influenced by small sample sizes or by different nonspecific study designs. This

might be the reason why a recent review recommends doing large, randomized control studies to confirm their clinical effect [4].

Algorithm for constipation management: a proposal

Despite these general measures, clinicians must be sure to follow a therapeutic algorithm to treat constipation:

First, set a good diagnosis of constipation: the initial parameters will be useful to determine the therapeutic indications and their efficacy [15]. Diabetes mellitus can affect the structure and function of the colon. Gastrointestinal autonomic neuropathy is an exclusion diagnosis [16]. One must exclude other causes of constipation, such as changes in microbiota or colorectal cancer, which are also more common in people with diabetes [17]. So, people with diabetes should be appropriately screened before starting therapeutic measures for constipation.

- Before starting, rule out mechanical obstruction, i.e., cancer, masses, or tumors. A complete physical exam, and a colonoscopy are indicated if the problem is new, the patient is older than 45, and has increased risks of cancer, such as diabetes. Rule out hypothyroidism or neurological problems as well [15].
- Gastroparesis and autonomic gastrointestinal neuropathy are late complications of long-term uncontrolled diabetes, and exclusion diagnoses. In these cases, intestinal peristalsis may be slow, which may cause gastric distension, bloating, slow intestinal transit, and constipation [16].
- Bowel peristalsis is also affected by hyperglycemia and hypoglycemia. Good glycemic control is imperative to reduce gastrointestinal symptoms and erratic glucose values in people with diabetes.
- Next, you must analyze if the patient is taking medications that have a constipating effect. Except for insulin, all antidiabetic drugs may have a constipating effect, as well as antihypertensives (beta-blockers, calcium channel blockers, ACE inhibitors. diuretics), antidepressants, opioid analgesics, lipid modifying agents, minerals, and vitamins [18].
- Then, make sure you´re not falling into a prescribing cascade. A prescribing cascade starts with the prescription of a new drug that causes an adverse side effect. This side effect is misinterpreted as a new medical condition. Then, a subsequent drug is prescribed, to treat the drug induced adverse event. This phenomenon was first described in 1995 [19].

For example, a first line prescription in type 2 diabetes is metformin, which can cause abdominal discomfort. Then, instead of changing the metformin or prescribing a less irritating presentation because of its side effect, the patient gets a prescription for a peptic ulcer/Gastrointestinal Reflux Disorder medication. The next side effect is constipation. Then the patient gets a fiber prescription.

This might be considered one of the least dangerous prescription cascades, since others, like those causing hyponatremia, can be mortal. Nevertheless, all prescription cascades must be identified and interrupted to increase medication safety in the elderly [19] and at all ages.

- The next step before prescribing a fiber supplement is to evaluate the patient's fiber intake: What is the total amount of dietary and functional fiber? What types of fiber is the patient consuming? What is the degree of processing of the viscous fibers? May some of the dietary fibers ingested cause constipation? Is the patient exceeding the recommended intake for a specific type of fiber?
- Lastly, after concluding which is the most probable cause of constipation in each case, the clinician must decide whether the patient needs more – or less- fiber intake, and which type of fiber would be best for his clinical condition, based on the mechanisms and scientific evidence by which each type of fiber may have clinical benefits.

Proposed algorithm for treating constipation

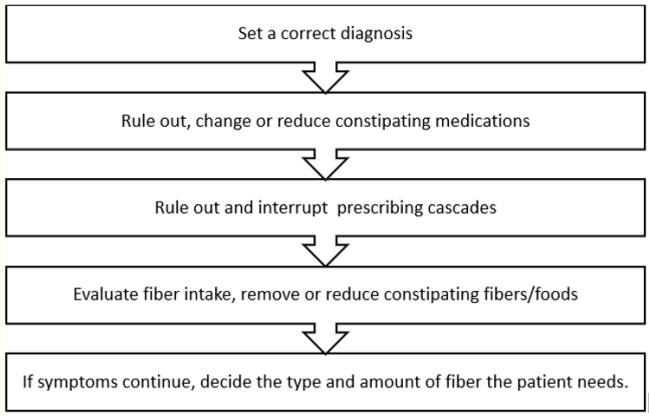

Figure a

Conclusion

Constipation is a very common symptom in type 2 diabetes mellitus, as well as in the general population. The current recommendations to treat constipation include increasing the amount of dietary fiber, water intake, and physical exercise. Despite these common treatment measures, there are strong controversies about the scientific evidence of the clinical effects of fiber intake and about what types and amounts of fiber that must be prescribed.

To have a laxative effect, dietary fibers must fulfill two prerequisites: (1) The fiber must resist fermentation. And (2) the fiber must resist dehydration.

The two mechanisms by which a fiber has a laxative effect are (1) by mechanical irritation of the mucosa or (2) by increasing stool water content.

Dietary fibers are not magic foods. Not all dietary fibers are the same or have the same properties. There is a strong controversy about the laxative effects of fermentable fibers (prebiotics, fructans, non-starch polysaccharides, hydrolyzed guar gum) because of several clinical studies that do not document positive results, or that even cause constipation. Excess of processed guar gum or pectins may cause constipation.

Coarse wheat bran is not an optimal treatment for constipation, since it works irritating the colonic mucosa, a counter-productive effect.

Finally, we propose an algorithm to treat constipation, starting with a good diagnosis and analysis of all factors that may cause constipation before starting a fiber supplement.

Disclosures

The author reports no conflicts of interest.

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