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The Beneficial Effects of Fiber on Major Chronic Diseases: A Review of Evidence

Fahime Zeinali; MSc[1], Mehnoosh Samadi; PhD[*2] & Niloofar Hojjati; MSc[2]

[1] Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[2] Department of Nutritional Sciences, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Kermanshah, Iran.

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***Corresponding author:**
mehnoosh_samadi@yahoo.com
Department of Nutritional Sciences, School of Nutritional Sciences and Food Technology, Kermanshah University of Medical Sciences, Beheshti Blvd, Kermanshah, Iran.

Postal code: 6719851351
Tel: 08337102009

ABSTRACT

Background: Fiber is a carbohydrate, which is neither completely digested nor absorbed in the small intestine, but may be fermented and plays a key role in the human health. We investigated the beneficial effects of fiber on major chronic diseases. **Methods:** It was extracted the relevant articles by searching the PubMed, ScienceDirect, and Scopus databases using the following keywords: dietary fiber, carbohydrate fermentation, short chain fatty acids, cardiovascular disease, diabetes, cancer, constipation, and appetite. In this research, a variety of studies were investigated including prospective cohort, case-control, cross-sectional, and clinical trial. The thematic relation of these studies was evaluated by reviewing their titles and abstracts. **Results:** From a total of 123 articles, 27 related studies with appropriate design and reliable information were selected and reviewed. Considering the selected studies, 13 were clinical trials, 10 articles were cohort, one was case-control, and three studies were cross-sectional. The studies investigated the beneficial effects of fiber on cardiovascular diseases (N = 4), type 2 diabetes (N = 8), appetite control and body weight (N = 3), colorectal cancer (N = 4), breast cancer (N = 2), immune system (N = 3), and constipation (N = 3). According to the results of this study, fiber reduces the rate of gastrointestinal discharges; this in turn leads to decrease of the glucose uptake and increases the satiety. More fiber consumption was associated with improvement of the immune system, weight control, reduction of the cardiovascular diseases, diabetes, colon cancer, and breast cancer. **Conclusions:** Regular consumption of fiber has beneficial health outcomes. However, these benefits depend largely on the types of the consumed fiber and the individual who intakes them.

Keywords: *Dietary fiber; Cardiovascular disease; Diabetes; Cancer; Constipation*

Introduction

In the 1950s, fiber was considered as an indigestible portion of the plants' cell wall (Robinson, 1956). More than half a century has passed and this definition has not changed yet. In 2002, the institute of medicine announced that the total fiber was calculated as the total of dietary fiber

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and functional fiber (Food and Nutrition Board (2002). Dietary, 2002). Dietary fiber contains indigestible carbohydrates and lignin, which are inherent in plants. Functional fiber contains indigestible and isolated carbohydrates, which have beneficial physiological effects on humans. Similar definitions of fiber are provided by governments and organizations around the world (Jones, 2014). As all definitions indicate, the carbohydrate fiber is neither completely digested nor absorbed in the small intestine, but it may be fermented in the large intestine (Asp *et al.*, 1988).

The nutrition facts panel recommends consumption of 25 g of fiber for a 2000 kcal diet (Wheeler and Pi-Sunyer, 2008). United States residents typically consume less than half the recommended fiber amount per day (about 15 g per day) (King *et al.*, 2012).

Several types of fiber exist including the soluble and insoluble fibers (Thompson *et al.*, 2005). In 2001, the fiber panel of physiotherapy institute recommended that characteristics such as viscosity and fermentation may be more important in predicting the health benefits of fiber in humans (Asp, 1987). Viscosity is similar to solubility and is often associated with water-retaining properties in fiber (Fuentes-Zaragoza *et al.*, 2010).

The evaluation of fiber fermentation is important, but it is difficult. Because fiber is not digested in the small intestine, it remains intact until reaching the large intestine when it is available for fermentation by the resident microflora. The result of this process is fermentation of the short-chain fatty acids (SCFAs), which will be available for absorption by colonocytes (Juskiewicz and Zdunczyk, 2004). Fiber fermentation is believed to play a key role in the health of the colon (Mikkelsen *et al.*, 2011). The insoluble puzzle is that viscosity and fermentation are two important features of fiber, but there is no "golden standard" to measure their properties (Rochus, 2013).

In general, an average meal is emptied from the stomach after about 2-5 hours, then, it is drained out of the small intestine after about 3 to 6 hours. Later, it remains in the large intestine 12 to 42 hours. Fiber may speed up or delay the process at any point in the gastrointestinal tract (Malagelada and Azpiroz, 1989). In studies on diabetics, fiber consumption was associated with a decrease in glucose uptake and prevented from weight gain (Ozougwu *et al.*, 2013).

Considering the importance of the role of fiber in health, this study examined the beneficial effects of fiber on major chronic diseases. So far and to the best of our knowledge, no study has ever assessed the beneficial effects of fiber on all chronic diseases.

Materials and Methods

In previous studies and systematic reviews, the relationship between fiber and various diseases was investigated. Among the studied diseases, cardiovascular diseases, diabetes, appetite control, body weight, colorectal cancer, breast cancer, immune system, and constipation had the most relationship with fiber. In order to conduct this simple overview, we searched throughout the PubMed, ScienceDirect, and Scopus databases using the following keywords: fiber, carbohydrate fermentation, SCFAs, cardiovascular disease, diabetes, cancer, constipation, and appetite. In our search, we found a variety of studies including cohort, case-control, cross-sectional, clinical trial. The thematic relation of studies was evaluated by reviewing the title and abstract of the articles. We only included the English human studies, which were conducted during 1999-2017 and investigated the relationship between fiber and chronic diseases. The exclusion criteria consisted of the review articles.

Results

We found a total of 123 articles (76 from PubMed, 32 from ScienceDirect, and 15 from Scopus) in our initial search. In the next step, 27 related studies with appropriate design and reliable information were selected and reviewed (**Figure 1**). Among the selected papers, 13 were clinical trials, 10 articles were cohorts, one was case-control, and 3 papers were cross-sectional. The beneficial effects of fiber on cardiovascular diseases was reported in 4 articles, on type 2 diabetes in 8 papers, on appetite control and body weight in three papers, on colorectal cancer in four articles, on breast cancer in two papers, on immune system in three articles, and on constipation in 3 papers.

Cardiovascular diseases (CVDs): American Institute of Medicine also indicated that adequate consumption of 14 g of fiber per 1000 kcal of consumed energy reduced the CVDs (Wheeler and Pi-Sunyer, 2008). Therefore, our findings are reliable regarding this relationship. Epidemiological studies showed that adequate and constant fiber intake reduced the risk of coronary artery disease (CHD) principally through reduced levels of low density lipoprotein (LDL) levels (Nordström and Thunström, 2009). For example, a meta-analysis conducted on 18 studies showed that the prevalence of CHD in people with the highest dietary intake of fiber was significantly lower than those with the lowest intakes (Hager *et al.*, 2011).

One of the intervention studies reported that water-soluble fibers (especially beta-glucan, psyllium, pectin, guar gum) were the most effective factors in reducing the serum LDL concentrations without affecting high density lipoprotein (HDL) concentration (Le Blay *et al.*, 2003). Claims that oat, barley, and pseudalumide were able to reduce the blood lipid levels were confirmed (Kashyap *et al.*, 2013). Although identification of the most beneficial types of fiber and their dosage is useful in preventing CVDs, this kind of information is not available (Grabitske and Slavin, 2008). However, **Table 1** summarizes the different types of fiber and their dosage briefly. The findings of a meta-analysis show reduction of LDL cholesterol levels (McClements *et al.*, 2008).

The results of clinical studies over the effects of fiber on CVDs suggest that fiber can play a useful role in reducing the level of C-reactive protein (CRP), apolipoprotein levels, and blood pressure (Jenkins *et al.*, 2002).

Type 2 diabetes (T2D): Many large-scale studies supported a reverse and strong relationship between fat intake and T2D. In a study of 5145 people, participants who consumed an average of 17.9 g fiber per day were significantly at lower risk of diabetes (Jenkins *et al.*, 2010). In another study, the risk of developing T2D in people who consumed large amounts of insoluble fiber (more than 59.1 g per day) was 34 percent lower than those who consumed 30.6 g of fiber per day (Bliss *et al.*, 2014). In the same study, the consumption of insoluble fats was not associated with the risk of diabetes (Elleuch *et al.*, 2011). Fiber-containing foods can reduce glucose and insulin levels compared to non-fiber foods (Mudgil and Barak, 2013). Several randomized controlled trials indicated that the blood glucose response to fiber-containing foods was likely to depend on fiber viscosity, fiber content, and food matrix (Fujii *et al.*, 2013).

It takes many years (and costs a lot) to conduct a therapeutic study for examining the effect of a long-term controlled diet including fiber in developing diabetes. Therefore, the most common method of examining this relationship is through studies that measure blood glucose response after consumption of fiber (Kristensen and Bügel, 2011). However, therapeutic studies offer conflicting results. For example, increase of the consumption of fiber p to four times at breakfast did not affect blood glucose levels (Wu *et al.*, 2015). Many of the exact tests failed to find a relationship between fiber intake and blood glucose after a meal (Visser *et al.*, 2010). However, the American Diabetes Association stated that serum glucose levels would generally be lower when the diet provided 30 to 50 g of fiber per day from all food sources, compared to low-fiber diets (Abutair *et al.*, 2016). It also suggested that dietary supplements that provided 10 to 29 g of fiber per day may have benefits in terms of blood glucose control (Blanco Canalis *et al.*, 2017).

Many theories proposed the relationship of fiber intake with T2D. For example, regular consumption of the recommended amount of fiber, reduction of the glucose uptake, prevention of weight gain, and more consumption of nutrients and antioxidants in the diet may help to prevent diabetes (Ozougwu *et al.*, 2013).

Appetite and body weight control: Consumption of fiber and satiety are related; the results of systematic reviews show that consumption of different amounts of fibers change the sense of satiety (Belalcazar *et al.*, 2014, Ye *et al.*, 2012). This relationship probably depends on many factors, including the type of fiber consumed (soluble and insoluble, viscous, or fermentable), fiber dose (1 g to 25 g), individual (male, female, obese, skinny, old, young), and the duration of fiber intake (once in lunch or daily intake for many years) (Wirstrom *et al.*, 2013).

Therapeutic studies on fiber and satiety provided contradictory results. It's clear that all fibers are not similar in terms of satiety. Viscose fibers, such as oat bran and psyllium may be more effective (Schulze *et al.*, 2004); whereas, insoluble fibers such as wheat bran and cellulose, which pass throughout the intestine, may also have a positive effect on satiety. In addition, fibers from all food sources may increase the sense of satiety more than the processed or isolated fiber in the same food (Post *et al.*, 2012).

Heaton explained how fiber consumption might reduce the energy intake, which could theoretically lead to weight loss (Amankwaah *et al.*, 2017). Today, prospective cohort studies consistently report that those who consume higher levels of fiber have less weight than those who consume less fiber (Amankwaah *et al.*, 2017). In fact, a study reported that 1 g of increase in total fiber consumed daily over a period of 20 months reduced body weight by 0.25 kg (Schulze *et al.*, 2004).

In most large-scale researches, fiber consumption changed with other factors in a healthy lifestyle, such as fruit and vegetable consumption as well as exercise habits. In addition, diets that are rich in fiber typically have lower levels of fat and energy density, both of which are useful in maintaining healthy body weight (Sluijs *et al.*, 2013). We should consider this factor because simply adding fiber supplements to the diet do not lead to the same results (Abutair *et al.*, 2016).

Considering clinical information, Howard et.al (Slavin, 2008) summarized the results of more than 50 therapeutic studies that assessed the relationship between intake of energy, body weight, and fiber intake. These studies estimated that the increase in fiber consumption up to 14 g per day caused a 10 percent reduction in energy intake and 2 kg reduction in weight over a period of approximately four months. The changes observed in the intake of energy and body weight occurred regardless of the type of fiber i.e., natural fiber or functional fiber.

Several mechanisms have been used to describe how the fiber affects the feeling of satiety and full satiety (saturation). Saturation is mainly the product of increasing the time of chewing some fiber-rich foods (Wirstrom *et al.*, 2013). Increase of the chewing time can cause saliva and gastric acid production, which may increase stomach bloating. Some soluble or viscosity fibers are bound to water, which may also increase bloating. Stomach bloating is believed to trigger feelings of satiety and saturation during meals and after meals (Bantle *et al.*, 2008). In addition, certain fibers can reduce the rate of gastric emptying and glucose absorption in the small intestine. In the case of slow release of glucose, the insulin response may also slow down. Although this is not always the case, slow and continuous glucose and insulin reactions after meals are occasionally associated with satiety and saturation feelings (Wanders *et al.*, 2011).

As the food moves through the upper and lower gut and intestine, various hormones related to the sense of satiety are released and signals are sent to the brain. Many of these intestinal hormones (ghrelin, YY polypeptides, and glucagon-like peptides) are thought to adjust satiety, food intake, and overall energy balance (Slavin and Green, 2007).

Stop in the intestinal tract may also affect the sensation of satiety. This inhibition feedback controls the transition of food through the gastrointestinal tract (Schroeder *et al.*, 2013). As the food gets out of the stomach by contraction and enters the small intestine, the distal messengers determine how fast the food passes through the gastrointestinal tract. By controlling the speed and movement of food swallowed, digestion and absorption of nutrients are optimized. The type and amount of nutrients that are used will affect the intestinal stop function; however, the role of fiber in activating intestinal stomata is not clear (Tucker and Thomas, 2009). Finally, certain types of fiber are mainly fermentable in the large intestine. The fermentation process was described as a potential reformer of satiety (Lattimer and Haub, 2010).

Colorectal cancer: In 1970s, many reports showed that the prevalence of colorectal cancer was due to low fiber diets (Heaton, 1973). These assumptions were largely based on the differences in the rates of colorectal cancer among nations and regions with high and low fiber consumption; this type of information clearly lacked the evidence of cause and effect. In the 1990s, the results of large-scale studies, including some therapeutic trials showed that fiber intake was not associated with the overall risk of colorectal cancer (Burkitt, 1971, Li *et al.*, 2012, Liu *et al.*, 2003). For example, an eight-year test on prevention of polyp (PPT) evaluated the effects of a high-fiber diet (18 g/1000 kcal), a diet rich in fruits and vegetables, and a low-fat diet on the return of adenomatous polyps in the large intestine (Giovannucci *et al.*, 1994). This study failed to demonstrate the effect of diet on the recurrence of adenoma after five years of follow-up. Probably, patients with adenoma recurrence were not good indicators of the development of colorectal cancer. However, this study has been the largest and the most comprehensive medical test. Perhaps the lack of relationship between high-protein diet therapy and the risk of colorectal cancer is likely true, but it may reflect a period of prolonged recession for the development of colorectal cancer. Moreover, poor dietary adherence among participants of this study may also weaken the strength of this relationship. When PPT participants reported that they exceeded all the dietary goals over a four-year period, they were subjected to subgroup analysis. Researchers found a 35 percent reduction in colorectal adenoma return compared to the control group (Steinmetz *et al.*, 1994). However, these people had a variety of lifestyle factors that were statistically different. Therefore, it is still not clear that fiber consumption protects against colon cancer (Burkitt, 1971). However, in recent studies, researchers hoped to find better options to understand colon changes during colon cancer development. They also aimed to investigate the association of these changes with fiber consumption.

Breast cancer: A systematic and meta-analysis review showed that fertility and obesity factors could affect estrogen, progesterone, and insulin levels; these are known as the potential risk factors for the development of breast cancer (Fuchs *et al.*, 1999). In another systematic and meta-analytic review, it was concluded that fiber intake reduced the risk of developing breast cancer, particularly by regulating the hormonal metabolism (Schatzkin *et al.*, 2007). This hypothesis is largely based on the fact that female vegetarians excrete more estrogen in their feces and their estrogen concentration in plasma decreases compared to women who consume animal proteins (Peters *et al.*, 2003). However, many prospective cohort studies have failed to find a link between the intake of fiber and the risk of breast cancer in women (Pierobon and Frankenfeld, 2013).

On the contrary, a review article reported that postmenopausal women who consumed more than 26 g of fiber per day were 13 percent less likely to develop breast cancer than the women who consumed less than 11 g of fiber per day (Pierobon and Frankenfeld, 2013). Reducing the risk of lobular tumors compared to ductal tumors, as well as estrogen and progesterone receptor-negative tumors compared to estrogen and progesterone receptor-positive tumors was more significant (Aune *et al.*, 2012). Cereal fibers, fruits, vegetables, and beans were not associated with the risk of breast cancer, while consumption of soluble (but not insoluble) fiber was found to be related with this cancer. This finding confirms that breast cancer is a complex disease and dietary factors such as fiber consumption are not likely to play a role in certain subtypes of cancer or menopause (Black, 1996).

Immune system: Some evidence suggests that immune system function improves with fiber consumption. The mechanism involves the presence or absence of some intestinal microflora. Probiotics and prebiotics are often used in fiber and immune system function discussions (Patterson *et al.*, 2010). Probiotics are tiny microorganisms that deliver health benefits to their host (Ferrari *et al.*, 2013). Prebiotics are indigestible foods that stimulate the growth or activity of beneficial bacteria in the large intestine (Park *et al.*, 2009). Probiotics are usually added to foods and products containing fiber,; whereas, prebiotics are often a type of fiber (fructooligosaccharides) (Slavin, 2013). Research on the potential benefits of probiotics and prebiotics for human health has continued for many years, although studies on the effects of these substances on the immune system and inflammatory processes are scarce and scattered. The effects of probiotics on immune system function, infection, and inflammation were studied in 2009. In general, the information showed that these relationships depend to a large extent on the examined species and races (Hill *et al.*, 2014). Lactobacillus and bifidobacterium are two species useful for different conditions (Anandharaj *et al.*, 2014). In a review, a similar survey was also conducted on prebiotics (Szkaradkiewicz and Karpiński, 2013) regarding human experiments. Ten trials of prebiotics including infants and children showed beneficial effects on infectious outcomes (Round and Mazmanian, 2009); whereas, 15 studies indicated little effect on adults (Rizzardini *et al.*, 2012).

*Constipation***:** A systematic review of 77 studies evaluated the effect of fiber intake on fecal excretion habits (Al-Sheraji *et al.*, 2013). A review article showed that all fiber sources increased the fecal production (Vandenplas *et al.*, 2013), although all fibers did not have the same role. For example, pectin (a kind of fiber in flesh of fruits such as apple) only increased the fecal weight by 1.3 g/g of fiber intake (Matsumoto *et al.*, 2007); whereas, wheat bran increased fecal weight by 5.7 g/g of fiber intake (de Vries *et al.*, 2015). This difference can be justified by the fact that the fecal weight largely depends on the distinctive properties of each fiber.

The role of fiber in feces is as follows: some fibers may hold more water than others, some fibers may degrade less over the gastrointestinal tract, and fermentable fibers may increase bacterial mass (Rose *et al.*, 2015). The degree of fermentation affects the feces mass, so that less fermentable fibers can increase the feces mass and have a laxative effect (Slavin and Feirtag, 2011). Fermented fibers also have the potential to produce feces, but this does not come from the fiber itself. Instead, fermentable fibers may increase the mass of bacteria, which can absorb water and increase feces volume (Ning *et al.*, 2014, Papanikolaou and Fulgoni, 2010). In general, larger stools are associated with a faster transfer through the large intestine that consequently cause less constipation (Brownlee, 2014).

This review had some limitations that should be mentioned. First, confounding factors were not considered. For instance, people with high dietary fiber intake tend to have other healthy behaviors such as being physically active, not smoking, or not drinking alcohols excessively. Another limitation is that we only included the human studies and did not consider the animal studies.

The strength of this review was that we considered all the diseases related to dietary fiber and collected all the beneficial effects of fiber on major chronic diseases from previous reviews.

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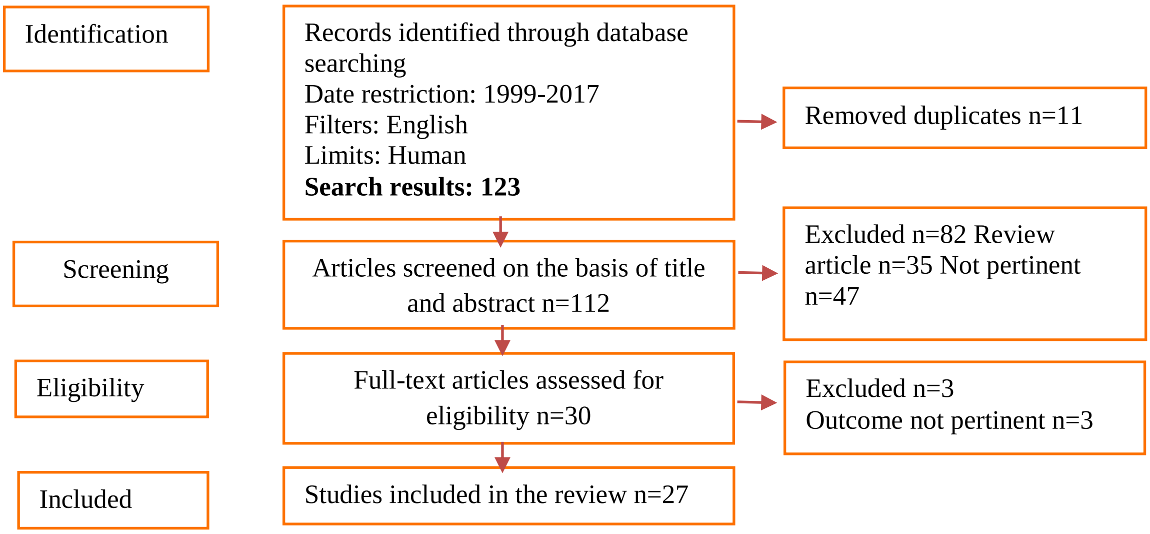

Figure 1. Flow-chart of study selection

Table 2. Effects of fiber consumption on serum LDL values

Type of fiber	Number of experiments	Number of people	The average added fiber per day (g)	Changes in LDL (reported as a change in treatment excluding placebo)
Pectin	5	71	15	-13.0
Beta-Glucan Barley	9	129	5	-11.0
Guar Gum	4	79	15	-10.6
Hydroxypropyl methyl cellulose	2	59	5	-8.5
Psyllium	9	494	6	-5.5

Numbers	Design	Year	Topic
24	Double-blind, randomized crossover study	2011	A diet rich in oat bran improves blood lipids and hemostatic factors, and reduces apparent energy digestibility in young healthy volunteers
51	Double-blind, randomized, placebo controlled global multicenter trial	2010	Apolipoprotein B synthesis inhibition: results from clinical trials
20	Randomized control trial	2016	Soluble fibers from psyllium improve glycemic response and body weight among diabetes type 2 patients
5,145	Randomized control trial	2014	Fiber intake and plasminogen activator inhibitor-1 in type 2 diabetes: Look AHEAD (Action for Health in Diabetes) trial findings at baseline and year 1.
5477	Prospective population-based study	2013	Consumption of whole grain reduces risk of deteriorating glucose tolerance, including progression to prediabetes
91249	Cohort	2004	Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women.
20	Randomized crossover trial	2017	Effects of Higher Dietary Protein and Fiber Intakes at Breakfast on Postprandial Glucose, Insulin, and 24-h Interstitial Glucose in Overweight Adults

29238	Case-cohort study nested	2013	Dietary glycemic index, glycemic load, and digestible carbohydrate intake are not associated with risk of type 2 diabetes in eight European countries.
252	Prospective cohort	2009	Increasing total fiber intake reduces risk of weight and fat gains in women
172	Cross-sectional	2012	An examination of sex differences in relation to the eating habits and nutrient intakes of university students.
74,091	Prospective cohort	2003	Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women.
Control: 33971 Case: 3591	Randomized control trial	2003	Dietary fibre and colorectal adenoma in a colorectal cancer early detection programme.
489611	Cohort	2007	Dietary fiber and whole-grain consumption in relation to colorectal cancer in the NIH-AARP Diet and Health Study.
521000	Prospective cohort	2013	Dietary fiber intake and risk of hormonal receptor–defined breast cancer in the European Prospective Investigation into Cancer and Nutrition study.
185598	Cohort	2009	Dietary fiber intake and risk of breast cancer in postmenopausal women: the National Institutes of Health–AARP Diet and Health Study
211	Randomised, double-blind, placebo-controlled	2012	Evaluation of the immune benefits of two probiotic strains Bifidobacterium animalis ssp. lactis, BB-12® and Lactobacillus paracasei ssp. paracasei, L. casei 431® in an influenza vaccination model a.
10	Double- blind, placebo- controlled, crossover	2007	LKM512 yogurt consumption improves the intestinal environment and induces the T-helper type 1 cytokine in adult patients with intractable atopic dermatitis.
12	Double-blind, randomized crossover study	2010	Chicory inulin does not increase stool weight or speed up intestinal transit time in healthy male subjects.
11113	cohort	2014	Associations of Dietary Fiber Intake With Long-Term Predicted Cardiovascular Disease Risk and C-Reactive Protein Levels (from the National Health and Nutrition Examination Survey Data [2005–2010]
47	Cross-sectional	2005	Gluten-free diet survey: are Americans with coeliac disease consuming recommended amounts of fibre, iron, calcium and grain foods?
23	Randomized crossover trial	2002	Effect of wheat bran on glycemic control and risk factors for cardiovascular disease in type 2 diabetes.
10	Randomized, controlled trial	2010	Effect of adding the novel fiber, PGX®, to commonly consumed foods on glycemic response, glycemic index and GRIP: a simple and effective strategy for reducing post prandial blood glucose levels
189	Randomized clinical trial	2014	Dietary fiber supplementation for fecal incontinence
4399	Cross-sectional	2013	Impact of dietary fiber intake on glycemic control, cardiovascular risk factors and chronic kidney disease in Japanese patients with type 2 diabetes mellitus: the Fukuoka Diabetes Registry.
88757	Prospective cohort	2000	Dietary fiber and the risk of colorectal cancer and adenoma in women
10914	Cohort	2013	Association of low dietary intake of fiber and liquids with constipation: evidence from the National Health and Nutrition Examination Survey.
49	Randomized-controlled clinical trial	2016	Inulin controls inflammation and metabolic endotoxemia in women with type 2 diabetes mellitus

Conclusions

The institute of medicine recommends consuming enough 14 g of fiber per 1000 kcal energy for all people over the age of one year. Based on the average energy consumption across the United States, this is about 25 g per day for women and 38 g per day for men aged 19 to 50 years. It is recommended for women and men of over 51 years old to consume 21 g and 30 g o fiber per day, respectively. The recommended amount of fiber for older people is reduced because the average energy consumption decreases with age (Wheeler and Pi-Sunyer, 2008).

Although the tolerable upper intake level (UL) is not recorded for fiber consumption, certain types of fiber may cause gas, bloating, abdominal pain, or unwanted changes in bowel movements. However, these effects are neither symptoms of fiber intake nor a sign of fiber poisoning (Yu *et al.*, 2014). The ability to tolerate fiber is widely differentiated among individuals. For example, in a study that participants consumed 10 g of inulin, some people did not report any complications; whereas, others reported multiple symptoms continuously for 48 hours (Kissileff *et al.*, 2003). These findings confirmed individuals' wide range of tolerances to fiber (de Graaf, 2012). In addition, some studies indicated that a high fiber diet was significantly associated with lower hormonal concentrations and a greater risk of ovulation (Norton *et al.*, 2015). High-fiber diet can also be associated with reduced absorption of minerals such as calcium, iron, and zinc(Sappok *et al.*, 2013). However, for the western societies, which usually consume low-fiber diet, reduction of mineral absorption is not a clinical problem (Roberfroid, 2005). In addition, research indicated that some fibers (for example, inulin) may actually increase calcium absorption in some communities (Markland *et al.*, 2013).

Finally, to conduct a study on fiber is difficult because it is often impossible to determine whether the results of fiber consumption are due to the consumption of the fiber itself or because of change in the density of the nutrients that contain fiber (Institute of Medicine, 2005). In particular, a high-fiber diet often increases the use of active biological compounds, such as plant materials and antioxidants that are not present in a low-fiber diet. Therefore, many epidemiological and therapeutic studies have shown that regular consumption of fiber is associated with beneficial health outcomes. However, these benefits largely depend on the type of fiber consumed and the individual itself (Dehghan *et al.*, 2014).

Further systematic reviews over the beneficial effects of fiber on major chronic diseases are needed.

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Authors' contribution

Samadi M conceived of the presented idea; Zeinali F, Hojjati N conducted and wrote the article and Samadi M supervised the findings of this work; all authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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