Dietary fibers and their effects on health

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Abstract

There are many observational data that documented the association of lower risk of cardiovascular abnormalities and dietary fiber consumption. Because humans cannot digest fibers due to lack of digestive enzyme. Carbohydrates are one of the indigestible form of dietary fiber. In nature the lignin and dietary fibers are found in plants and are classified on the basis of solubility as soluble and insoluble fibers. They’re found in several fruits, vegetables, grains, and wheat. There are number of ways present through which soluble fibers have been shown to help in lowering the blood cholesterol level. The non-soluble dietary fibers include lignin, hemicellulose, and cellulose; these fibers are abundant in whole-grain meals, bran, nuts, and seeds. Water-insoluble fibers may minimize intestinal transit time and increase fecal volume, promoting digestive regularity, due to their quick stomach emptying. The functional fibers are isolated and extracted form of dietary fibers that have more fitness benefits when included to food nutrients during the processing of emptying the stomach. The daily allowances that are recommended for men and women aged 19-50 are 38 g/day of the total fiber that is consumed per day, discretely. The important point is that the RDS recommendation is only for fit and healthy peoples and not applicable on the people having any chronic disorders. According to studies, the majority of Americans do not follow the RDA instruction of taking dietary fibers strictly. The present state of knowledge about dietary fiber, fiber sources, and heart disease risk reduction will be discussed in this review.

Keywords: Fiber composition; dietary fiber; soluble fiber; non-soluble fiber; groups of food; cardiovascular disease

Introduction

The heart disease in United States is one of the leading cause of morbidity and mortality. The report of National Vital Statistics Service showed that the cerebrovascular disorders were the fifth greatest factor in 2016 of death (1). For decreasing the level of low-density lipoprotein cholesterol (LDL-C), Statins are found helpful medication in major cases of atherosclerotic cardiovascular disorders, to date (2). Statins lower blood cholesterol levels by blocking the 3-hydroxy-3-methylglutaryl-coenzyme A (HMG CoA) Reductase enzyme, this is the third step in the synthesis of endogenous cholesterol. Non-statin medications were shown to be ineffective in lowering blood cholesterol in clinical studies due to concerns with toleration or less advantages of fitness (3). Moreover, in case of required high dose of statin therapy may leads to complications and also expensive. Furthermore, statin non-adherence and dropout rates have increased, and yet many at-risk patients fail to reach adequate LDL-Cholesterol reduction with statin mono-therapy (4). The dietary fibers are used with statin as a dietary supplement in order to enhance the efficacy, health benefits and decrease the dose of statin. The most recent meta-analysis documented that soluble fiber improves the efficacy of statin (5).

Furthermore, eating whole cereals, which are abundant in dietary fiber, was connected to improved statin benefits in lowering blood cholesterol, according to NHANES cross-sectional data (2003–2006) (6). In Germany, since 1850, Animal feeds have been used to make crude fibers (7).
During 1954, South African Bantu reported that the decreasing in the cholesterol and lipid level is due to the effect of dietary fiber (8). Fisher discovered that for a year and a half, cockerel fed a 5% pectin-supplemented food stored and excreted two times more cholesterol and three times greater fat as cockerel fed a regular food (8). The research on the effects of dietary fiber on lipid digestion was reported by the cockerel in 1964 (9). The goal of this review is to emphasize the advantages of soluble gel-forming fiber as a supplement to statins for decreasing blood cholesterol, which is a symptom of cardiovascular disease.

**Metabolism and Chemistry of Fiber**

Dietary fibers are high in carbohydrates and lignin, which are not degraded by enzymes present in humans and hence are not breakdown or suck up (10). Plants have intact dietary fiber, which is made up of from the subunits of complex polymer of phenylpropanoid. Soluble fiber is a type of fiber present in plants that is not digested completely but can be converted into pieces in large intestine in the form of short-chain fatty acids by colonic bacteria. On the other hand, non-soluble fiber, passes through the digestive system without being broken down (11).

Non-soluble fibers include cellulose, some hemicellulose, and lignin. The hydrogen bond that exists between glucose residues results in cellulose its three-dimensional structure. Cellulose is an extended linear polymer made up of β(1–4) glucose units bonded together.

Hemi-cellulose is made up of hexose and pentose sugars linked by (1–4) bonds in the backbone and glucuronic, arabinose, and acid galactose, bonded by β (1–2) and (1–3) in the side chain. Lignin is made up of highly branched phenol polymers through well-built intramolecular connections (11). The example of soluble fiber includes pectin, gums, mucilage made from psyllium husk, β-glucan, and fructans, as well as some hemicellulose.

A heterogeneous polysaccharide Pectin is made up of straight chains of α (1–4)-linked D-galacturonic acid backbone with pentose and hexose chains attached to it. Gums include a galactose backbone attached by β (1–3) and β (1–6) bonds with galactose, methyl-glucuronic acid, glucuronic acid, or arabinose side chains and are released where injury is present at plant. Mucilage is a sticky, gel-forming liquid-soluble fiber found in the plant psyllium that contains up to 80% soluble polysaccharide and is structurally similar to gums. β-glucans, and apart from these, are homopolymers of simple sugar subunits, and fructans, which include oligofructoses and inulin, are polymers of fructose.

In humans, soluble fiber is sensitive to contamination by enzymes present in small intestine, however, bacteria in the intestinal tract degrade it into simple fatty acids (SCFA). The creation of SCFA causes changes in the gut flora, which adds to soluble fiber's hypocholesterolemic effects (12). Dietary fiber fattens up the food, dissolve and isolate cholesterol, and therefore reduces the consumption capability of liver while boosting the release of bile and fecal lipids and bile acids.

**Fibers in the diet and in the body**

Dietary fibers, which comprise both soluble and non-soluble fibers are the important components of a healthy diet, are carbohydrates and lignin which is not digested found in plants. The primary and secondary walls of the herb cell wall make up the majority of the dietary fiber content.

Dietary fibers are characterized depending on how well they dissolve in hot water, how much water they can hold (hydration), and how viscous they are in nature (7,13).

Viscous fibers like -glucans, fructans (mulin, fructooligosaccharides), gum, pectin, and mucilage, as well as non-viscous fibers like hemicellulose, are all soluble fibers. Soluble fibers store water and form a gel, which slows digestion by increasing food transit time, delaying stomach digestion process, limiting nutrient uptake, and delaying digestion. Soluble fiber can be found in vegetables like onion, broccoli, carrots, and artichokes, as well as fruits like pears, berries, bananas, apples, and oats, legumes, and barley. Non-soluble fibers include lignin,
cellulose, and hemicellulose. Non-soluble fiber, unlike soluble fiber, reduces transit time and increases fecal volume, which aids in constipation relief. Insoluble fibers can be found in whole cereals, oats, flour, nuts, and seeds, as well as a variety of fruits and vegetables. While both soluble and non-soluble fibers are indigestible and can be digested by bacteria, because of having enzyme for digestion. The soluble fibers can be simply fermented by gut microbiota and therefore works as a great source of SCFAs. Finally, SCFAs can be entered from colonic environment and oxidized for the purpose of energy generation. SCFAs entrance has been documented to decrease the synthesis of cholesterol in liver which in turn contribute to the decrement in blood cholesterol level and elevated water and sodium entrance into the colonic mucosal cells [14,15].

SCFAs also take part in making acidic colon luminal environment that decreases the dissolvability of free bile acids, improves the excretion of bile, and reduces the transformation of free bile acids to secondary and more toxic bile acids. Functional fibers, on the other hand, are indigestible sugars which are obtained, isolated, or produced and created, and are implicated in positive health consequences in human being. The most common examples of functional fibers include: β-glucans, cellulose, chitins, and chitosan, fructans, gums, lignin, pectin, polydextrose and polys, psylliums, resistant dextrins, and resistant starches [7]. Prebiotics to be considered as a kind of functional fiber which enhances the host’s health by increment in the activity or growth of health-promoting bacteria in the colon, primarily bifidobacteria and lactobacilli [18]. In order to come under the umbrella of prebiotics, fibers should resist in digestion via human enzymes and therefore, they must not be hydrolyzed and absorbed; have the ability to persist in the acidic environment of stomach and finally should be fermented by colon inhabitant bacteria [18]. The most common examples of prebiotics are Galacto-oligosaccharides, fructooligosaccharides (fructans), and lactulose.

**Intakes of Dietary Fiber Recommendations**

Dietary Reference Intake (DRI) daily allowances for males aged 19–50 years and women aged 25 years are 38 g/day and 25 g/day, respectively, while for men over 51 years is 31 g/day and women over 51 years is 21 g/day. 19 g/day is recommended for infants ages 1–3, and 25 g/day is recommended for children ages 4–8. For 9–13-year-old boys, the DRI guidelines are 31 g/day and 38 g/day. The DRI recommendation for girls ages 9–18 is 26 g/day. Despite the fact that dietary fiber has been demonstrated to provide a number of health benefits, most Americans consume only 15 grams per day, which is far less than the recommended amount. [19]. Fiber intake has no maximum limit, but tolerance varies by person, and the most common negative effects of excessive fiber consumption include bloating and gastrointestinal pain.

**Fiber and Cholesterol in the Blood**

**Studies of Animals**

In rats, isomaltooltrax treatment was related with lower fat absorption relative to the control vehicle, and this effect lasted for up to 6 hours [20]. The mechanism was attributed to enhanced micelle stability and larger particle size, according to the authors. In guinea pigs, our team discovered that feeding pectin, guar gum, or psyllium boosted LDL-ApoB 100 turnover, which resulted in upregulation of hepatic LDL receptors, resulting in quicker catabolism and elimination [21–25]. Furthermore, fiber's hypocholesterolemia effect was due to a decrease in the number of secreted VLDL particles, as well as a decrease in cholesteryl ester transfer protein (CETP) activity, resulting in lower cholesteryl ester in VLDL particles that are transferred to LDL, and increased VLDL and LDL apo B 100 turnover [21]. Dietary fibers have been shown to reduce the risk of heart disease and the mortality associated with cardiovascular disease in a variety of animal models. Lo et al. (1987), for example, found that soybean dietary fiber was helpful in reducing atherosclerosis in rabbits [26].

Similarly, grapefruit pectin was found to decrease atherosclerosis in miniature swine by Beakley et al. (1988) [27]. For 3.5 years, McCall et al (1992) compared the intake of low-cholesterol cellulose (LCC), high-cholesterol psyllium (HCP), and high-cholesterol cellulose (HCC) in African green monkeys, finding that both LCC and HCP greatly decreased blood cholesterol compared to HCC, and that dietary psyllium decreased total blood cholesterol.
by lowering LDL cholesterol formation [28,29]. In rats, Roach and Topping et al. (1990, 1992) found that combining oat bran and fish oil reduced blood cholesterol levels [30,31]. Wilson and colleagues also discovered that in Syrian Gold Hamsters, barley and insoluble fibers had a hypocholesterolemia impact [32–34]. Similarly, multiple studies have shown that particular forms of dietary fiber can help mice lower their blood cholesterol levels [35–41]. Studies in animal models show that both soluble and insoluble fibers are important in lowering blood cholesterol, reducing atherosclerosis, and lowering the risk of heart disease.

**Studies on Human**

**Observational Studies**

Several cohort studies in the United States and around the world have looked at the relationship between dietary fiber intake and coronary heart disease and cardiovascular disease [42–53]. Dietary fiber was found to have a preventive effect against heart disease in these trials. Pereira et al. (2004) performed a meta-analysis of ten cohort studies with a follow-up period of 6–10 years [44]. With a Relative Risk (RR) of 0.84 (95 percent CI, 0.70–0.99), the researchers found an inverse connection between dietary fiber consumption and the risk of cardiovascular disease. However, an increase in fiber consumption of 10 grams per day had no statistical significance, with a relative risk of 1.0 (95 percent CI 0.88–1.13). Threapleton and colleagues (2013) conducted a meta-analysis to assess the dose–response association between dietary fiber consumption and cardiovascular disease risk [54]. The pooled preventive impact for each 7 g/day increase in fiber consumption was RR = 0.91, according to the researchers (CI 0.87 to 0.94). Higher fiber doses, on the other hand, exhibited a wider confidence interval around the mean, making the findings less credible [54]. Furthermore, in the Prevencion con Dieta Mediterranea (PREDIMED) trial, Buil-Cosiales and colleagues (2014) found that fruit fiber intake was linked to lower all-cause mortality (Hazard Ratio 0.59, 95 percent CI = 0.44, 0.78) [55]. Throughout the last three decades, several researchers have demonstrated the benefits of dietary fiber from a diversity of food causes in reducing the risk of heart disorders. [54,56–62]. As a result, founded on the information, it seems that fiber intake should be limited.

Bias and confounding variables are two major drawbacks of observational research [62]. In addition, rather than demonstrating causation, relationships and correlations are shown. Assortment preference can occur in cohort studies as a result of instructive editing and quantity mistakes, and in case-control studies as a result of inadvertent control selection. Confounding may emerge as a result of the coexistence of exposures that result in the same health effect. It's difficult to account for confounding unless you know all of the frequent reasons of coverage and their links to the illness results. To explore the interconnection of fiber in decreasing heart disease, death and to minimize confounders, size faults, and choice preference, trials with a randomized control group investigations are done (63).

**Other Functions of Fiber**

Dietary fiber protects against chronic infections such heart disease, diabetes, metabolic condition, irritable bowel disorder, diverticular disease, obesity, and colon cancer in an age-adjusted study. Insoluble fiber, for example, impasses to and adsorbs carcinogens, mutagens, and poisons, reducing their negative special effects on the body by blocking contaminants from being absorbed and directing them to be eliminated. Delay in intestinal passage period, prolonged satiety and satiation after a meal, and production of the cholecystokinin, leptin are all fiber features. Increasing fiber intake by eating more whole grains, fruits and vegetables, nuts and legumes, according to the Academy of Nutrition and Dietetics, is associated to a subordinate risk of type 2 diabetes, cardiovascular disease, and certain malignancies [64].

**Conclusion**

Dietary fiber would be used to supplement statin monotherapy in decreasing entire and Low Density Lipoprotein-Cholesterol, as well as to decrease the statin intake, reduce adverse effects, and improve drug acceptability. Dietary fibers in whole foods, both soluble and insoluble, have a variety of non-nutritive fitness
properties that help to improve lipoprotein outlines and have no caloric value, so they can be included in a balanced intake design. Whole grains, protein foods, fruits, and vegetables have a lot of dietary fiber, which makes them particularly suitable for disease anticipation and lowering the risk of cardiovascular disease and atherosclerosis.

References


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