Dietary Fiber Intake and Type 2 Diabetes Mellitus: An Umbrella Review of Meta-analyses

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ABSTRACT

Objective: The purpose of this study was to review previously published meta-analyses on the effectiveness of dietary fiber on type 2 diabetes.
Methods: An umbrella review of all published meta-analyses was performed. A PubMed search from January 1, 1980, to April 30, 2017, was conducted using the following search strategy: (fiber OR glucan OR psyllium) AND (meta-analysis OR systematic review). Only English-language publications that provided quantitative statistical analysis on type 2 diabetes, fasting blood glucose concentrations, or glycosylated hemoglobin were retrieved.
Results: Sixteen meta-analyses were retrieved for inclusion in this umbrella review. In the meta-analyses comparing highest versus lowest dietary fiber intake, there was a statistically significant reduction in the relative risk (RR) of type 2 diabetes (RR = 0.81-0.85), with the greatest benefit coming from cereal fibers (RR = 0.67-0.87). However, statistically significant heterogeneity was observed in all of these meta-analyses. In the meta-analyses of supplementation studies using β-glucan or psyllium fibers on type 2 diabetic participants, statistically significant reductions were identified in both fasting blood glucose concentrations and glycosylated hemoglobin percentages.
Conclusion: This review suggests that those consuming the highest amounts of dietary fiber, especially cereal fiber, may benefit from a reduction in the incidence of developing type 2 diabetes. There also appears to be a small reduction in fasting blood glucose concentration, as well as a small reduction in glycosylated hemoglobin percentage for individuals with type 2 diabetes who add β-glucan or psyllium to their daily dietary intake. (J Chiropr Med 2018;17:44-53)
Key Indexing Terms: *Blood Glucose; Dietary Fiber; Diabetes Mellitus, Type 2; Hemoglobin A, Glycosylated*

INTRODUCTION

The Centers for Disease Control and Prevention estimates there are 30 million people with type 2 diabetes in the United States, and most will, at some point in their life, develop some form of vascular complication.[1] These vascular complications can present in the form of microvascular disease (retinopathy, nephropathy, and neuropathy) and/or macrovascular disease (coronary heart disease, stroke, or peripheral artery disease).[2,3] These serious complications of diabetes confer substantial morbidity and impair patient quality of life. It has been estimated that diabetes costs the United States more than $174 billion per year when taking into account medical costs and loss of productivity.[4]

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Both microvascular and macrovascular complications are thought to be due to prolonged hyperglycemia, which promotes an increase in oxidative stress, inflammation, and vascular damage.[2,3] Evidence indicates that medical interventions designed to lower blood glucose concentrations can reduce the risk of developing microvascular and macrovascular complications.[5] One of these interventions includes a low glycemic index diet. Because increased fiber content decreases the glycemic index of foods, the American Diabetes Association encourages diabetics to consume a variety of fiber-containing foods.[6] Unfortunately the blood glucose–lowering effects of fiber intake have not been consistently reported in the literature, with some clinical intervention studies reporting improvements in fasting blood glucose control and glycosylated hemoglobin (HbA1c) percentages,[7-10] but others reporting no improvement.[11-15]

Many of the clinical trials conducted to study the effects of dietary fiber intake on type 2 diabetes may have had sample sizes that did not provide sufficient statistical power to detect small, potentially meaningful changes in effect. Given the inconsistency of the existing literature and the insufficient statistical power as a result of small sample sizes, a pooling of information from individual trials could

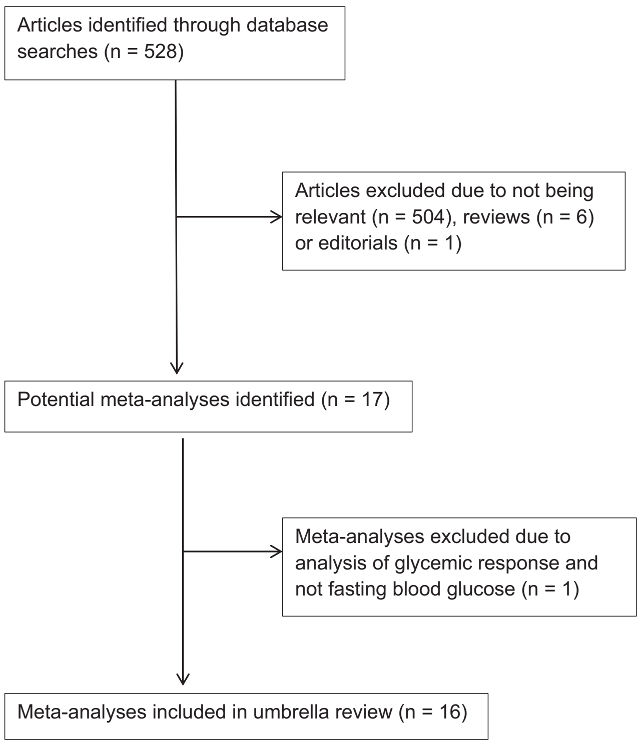

Fig 1. *Flow chart of meta-analysis selection.*

provide a more precise and accurate estimate of dietary fibers role in reducing the incidence of type 2 diabetes. To achieve this result, many investigators have turned to performing a powerful statistical method known as meta-analysis. Meta-analyses are fundamental in providing the highest level of evidence to best inform health care decision making. Therefore, the purpose and objective of this paper is to summarize the evidence from previously published meta-analyses regarding the effectiveness of dietary fiber as a therapeutic agent for type 2 diabetes.

Methods

An umbrella review was selected for this study. An umbrella review provides a summary of existing published meta-analyses and systematic reviews and determines whether authors addressing similar review questions independently observe similar results and arrive at similar conclusions.[16]

Because meta-analyses began appearing in medical literature in the early 1980s, a systematic literature search of PubMed and CINAHL from January 1, 1980, to April 30, 2017, was conducted using the following search strategy: "(fiber OR fibre OR chitosan OR fructan OR glucan OR gums OR inulin OR lignin OR pectin OR psyllium OR bran) AND (meta-analysis OR systematic review)." The titles and abstracts from the literature search were scanned, and only English-language publications that provided quantitative statistical analysis on type 2 diabetes, fasting blood glucose concentrations, and glycosylated hemoglobin were retrieved. Meta-analyses or systematic reviews that did not present study-specific summary data using a minimum of 4 randomized controlled trials were excluded.

Table 1. *High vs Low Dietary Fiber Intake on the Incidence of Developing Type 2 Diabetes*

Meta-analysis Authors and Date	No. of Studies in Meta-analysis	No. of Participants in Meta-analysis	Total Dietary Fiber Relative Rate; *P* Value; Q-Test *P* Value; I^2 Statistic; Publication Bias *P* Value	Cereal Fiber Relative Rate; *P* Value; Q-Test *P* Value; I^2 Statistic; Publication Bias *P* Value	Fruit Fiber Relative Rate; *P* Value; Q-Test *P* Value; I^2 Statistic; Publication Bias *P* Value	Vegetable Fiber Relative Rate; *P* Value; Q-Test *P* Value; I^2 Statistic; Publication Bias P Value
Schulze et al, 2007[18]	9	432 730		0.67, $P < .05$ 0.04, NR NR	0.96, NS NS, NR NR	1.04, NS NS, NR NR
Ye et al, 2012[19]	10	350 241	0.84, $P < .05$ 0.04, 44% NS	0.87, $P < .05$ 0.001, 74% NS		
Yao et al, 2014[17]	11	359 167	0.81, $P < .05$ 0.014, 54% NS	0.77, $P < .05$ 0.011, 56% 0.004	0.94, NS NS, 29% NS	0.95, NS 0.008, 60% NS
InterAct Consortium, 2015[21]	14	414 711	0.85, $P < .05$ 0.002, 61% NS	0.77, $P < .05$ 0.001, 78% 0.004	0.95, NS NS, 17% 0.04	0.96, NS 0.04, 48% 0.000
Wang et al, 2015[22]	11	448 287			1.00, NS NS, 1.5% NS	0.94, NS 0.005, 53% NS

NR, not reported; *NS,* not significant.

Table 2. *Effects of Increased Fiber Intake on Changes in Fasting Blood Glucose Concentrations*

Meta-analysis Authors and Date	No. of Studies in Meta-analysis	No. of Participants in Meta-analysis	Fiber Type and Dose/ Day	Mean Duration in Weeks	Reduction in Fasting Blood Glucose Concentration in mg/dL	Q Test *P* Value and I^2 Statistic	Egger or Begg Test *P* Value	Quality Assessment and Outcome
Post et al, 2012[23] [a]	13 T2D	400	Soluble 18 g	8	↓ 15.3, $P < .001$	NS, 5%		GRADE 9/13 high quality
Silva et al, 2013[24]	8 T2D	496	Soluble 11 g	12	↓ 10.0, $P < .05$	$P < .001$, 96%	NS	GRADE NR
Tiwari and Cummins, 2011[25]	22	487	β-Glucan 6 g	6	↓ 44.6, $P < .001$	$P < .001$, 97%	NS	
Bao et al, 2014[26]	12	630	β-Glucan 5.5 g	8	↓ 0.7, NS	$P < .001$, 68%	NS	Jadad scale 7/12 high quality
Zhu et al, 2015[27]	8	378	β-Glucan 5 g	6.5	↓ 0.4, NS	NS, 0%	NS	Jadad scale 4/8 high quality
Zou et al, 2015[28]	12	603	β-Glucan 5 g	6	↓ 0.9, NS	NS, 0%	NS	Jadad scale 7/12 high quality
Hou et al, 2015[29]	6 T2D	437	β-Glucan NR	4.5	↓ 7.0, $P < .001$	NS, 0%		NOS 5/6 high quality
Shen et al, 2016[30]	4 T2D	239	β-Glucan 3g	4.5	↓ 9.4, $P < .01$	NS, 0%	NS	Cochrane 3/4 high quality
He et al, 2016[31]	16	933	β-Glucan 5.5g	7.5	↓ 2.3, $P < .01$	$P < .001$, 99%		
Gibb et al, 2015[32]	4 T2D 14	245 1267	Psyllium 12g Psyllium 10 g	8.5 9.5	↓ 37.0, $P < .05$ ↓ 1.6, NS	$P < .05$, 61% $P < .05$, 68%		
Liu et al, 2016[33]	15	579	Fructans 12.5 g	7.5	↓ 0.9, NS	NS, 26%	$P < .05$	Cochrane 4/15 high quality

NOS, Newcastle-Ottawa Scale; *NR,* not reported; *NS,* not significant; *T2D,* participants with type 2 diabetes only.
[a] Low-quality score on the Critical Appraisal Checklist for Systematic Reviews.

For 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 (such as fasting blood glucose concentrations or glycosylated hemoglobin percentages), and/or summary relative risks. Although not always present, the meta-analyses were also analyzed for their disclosure of quality assessment, statistical heterogeneity (Cochrane *Q* test and I^2 statistic) and publication bias (visual inspection of funnel plots and Egger or Begg regression test). A methodological quality appraisal was conducted for all meta-analyses using the Critical Appraisal Checklist for Systematic Reviews, which was developed by the Umbrella Review Methodology Working Group.[17] This checklist consists of 10 items where each item within the instrument can receive 1 point for an overall quality score that could range from 0 to 10. Meta-analyses with quality scores ranging from 0 to 4 were labeled as low quality, those with scores between 5 and 7 as medium quality, and those with scores of 8 to 10 as high quality. Because this is a descriptive summary review of meta-analyses, no statistical analyses were performed.

Results

The initial search strategy identified 528 articles and, after careful review, 17 meta-analyses were retrieved for inclusion into this umbrella review.[17-33] One meta-analysis was excluded because it analyzed studies that administered a soluble fiber (resistant maltodextrin) for acutely reducing glycemic response with participants on a high-carbohydrate diet.[20] A flow chart of the meta-analyses selection process is provided in Figure 1.

In regard to the methodological quality of the remaining 16 meta-analyses in this umbrella review, the mean quality appraisal score was 8/10, where 12 (75%) meta-analyses satisfied high-quality scoring between 8 and 10; 3 (19%)

Table 3. *Citation Matrix for Meta-analyses on β-glucan Supplementation Studies*

Studies	He et al, 2016[31] 16 citations	Shen et al, 2016[30] 4 T2D citations	Hou et al, 2015[29] 6 T2D citations	Zou et al, 2015[28] 12 citations	Zhu et al, 2015[27] 8 citations	Bao et al, 2014[26] 12 citations	Tiwari and Cummins 2011,[25 a] 22 citations
Ballesteros et al, 2015[34]			Yes				
Beck et al, 2010[35]	Yes					Yes	
Biorklund et al, 2005[36]	Yes			Yes	Yes	Yes	Yes
Biorklund et al, 2008[14]	Yes			Yes	Yes	Yes	Yes
Charlton et al, 2012[37]				Yes	Yes		
Cugnet-Anceau et al, 2010[12]	Yes	Yes	Yes			Yes	
Davy et al, 2002[38]	Yes					Yes	
DeNatale et al, 2012[39]				Yes			
Granfeldt et al, 2008[40]						Yes	Yes
Johansson et al, 2014[41]				Yes			
Kabir et al, 2002[42]	Yes	Yes	Yes				
Keogh et al, 2003[43]				Yes			
Li et al, 2011[44]	Yes						
Liatis et al, 2009[45]		Yes	Yes			Yes	
Lovegrove et al, 2000[46]	Yes			Yes	Yes		
Ma et al, 2013[47]	Yes	Yes	Yes				
Maki et al, 2007[48]						Yes	
McGeoch et al, 2013[11]						Yes	
McIntosh et al, 1991[49]				Yes	Yes		Yes
Onning et al, 1999[50]				Yes	Yes		
Queenan et al, 2007[51]	Yes			Yes	Yes	Yes	

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Table 3. (*continued*)

Studies	He et al, 2016[31] 16 citations	Shen et al, 2016[30] 4 T2D citations	Hou et al, 2015[29] 6 T2D citations	Zou et al, 2015[28] 12 citations	Zhu et al, 2015[27] 8 citations	Bao et al, 2014[26] 12 citations	Tiwari and Cummins 2011,[25 a] 22 citations
Reyna et al, 2003[52]			Yes				
Reyna-Villasmil et al, 2007[53]	Yes					Yes	
Rondanelli et al, 2011[54]				Yes	Yes		
Saltzman et al, 2001[55]	Yes					Yes	
Stevens et al, 1985[56]	Yes						
Tighe et al, 2010[57]	Yes						
Uusitupa et al, 1992[58]	Yes						
Zhang et al, 2012[59]	Yes			Yes			

T2D, participants with type 2 diabetes only.
[a] In the meta-analysis by Tiwari and Cummins,[25] only 4 of the 22 citations were common to those listed here. The total number of individual citations combined for all 7 meta-analyses is 47, and 29 are cited only once (62%).

satisfied medium-quality scoring between 5 and 7; and 1 (6%) satisfied low-quality scoring with a score of 4 out of 10. Although the meta-analysis by Post et al[23] had been deemed lower quality, it was still included in this umbrella review because it provided useful information regarding the effectiveness of dietary fiber as a therapeutic agent for people with type 2 diabetes.

The meta-analyses presented in Table 1 are based on dietary surveys that compare the highest versus lowest daily dietary fiber consumption on the incidence of developing type 2 diabetes. For populations that consumed the highest dietary fiber intake, the incidence of type 2 diabetes was significantly reduced in all 3 meta-analyses, with the relative risk ranging between 0.81 and 0.85 (Table 1). However, for all 3 meta-analyses, statistically significant heterogeneity was noted. For populations that consumed the highest cereal fiber intake, the incidence of type 2 diabetes was significantly reduced in all 4 meta-analyses, with the relative risk ranging between 0.67 and 0.87. But again, statistically significant heterogeneity was noted in all 4 meta-analyses, as well as statistically significant publication bias being identified in 2 of the 4 meta-analyses. In the 4 meta-analyses that compared populations consuming either the highest intakes of fruit or vegetable fiber, there was no statistically significant difference in the incidence of developing type 2 diabetes when compared with those consuming the lowest intakes. The relative risks ranged between 0.94 and 1.04 in both the fruit and vegetable fiber categories.

The 2 meta-analyses that analyzed clinical studies administering soluble fiber supplementation in participants with type 2 diabetes reported statistically significant reductions in fasting blood glucose concentrations of 15.3 and 10.0 mg/dL (Table 2). It appears that a higher average daily dose of 18 g/day of soluble fiber resulted in a greater reduction in fasting blood glucose concentrations compared with the lesser dose of 11 g/day. In the 7 meta-analyses that analyzed clinical studies that exclusively used β-glucan supplementation, there were mixed results; only 4 of the 7 meta-analyses reported statistically significant reductions in fasting blood glucose concentrations. With the 4 meta-analyses that reported statistically significant reductions in blood glucose concentrations, the changes noted included 2.3, 7.0, 9.4, and 44.6 mg/dL. However, statistically significant heterogeneity was identified in 2 of the 4 of these meta-analyses. There is considerable heterogeneity in the individual clinical studies selected and used by these 7 meta-analyses on β-glucan supplementation: 62% of the 47 individual citations were used only once (Table 3).[11,12,14,34-59]

The meta-analysis on psyllium supplementation was only statistically significant for the participants with type 2 diabetes with a fasting blood glucose reduction of 37.0 mg/dL, but again there was statistically significant heterogeneity. The meta-analysis on fructan supplementation studies identified no statistical significant reduction in fasting blood glucose concentrations.

Table 4. *Effects of Increased Fiber Intake on Changes in Fasting Insulin Concentrations*

Meta-analysis Authors and Date	No. of Studies in Meta-analysis	No. of Participants in Meta-analysis	Fiber Type and Dose/Day	Mean Duration in Weeks	Reduction in Insulin Concentrations in pmol/L	Q Test *P* Value and I^2 Statistic	Egger or Begg Test *P* Value	Quality Assessment and Outcome
Bao et al, 2014[26]	9	496	β-Glucan 5.5 g	8	↓ 6.3, $P < .05$	NS, 0%	NS	Jadad scale 6/9 high quality
Zou et al, 2015[28]	6	283	β-Glucan 3.5 g	6	↓ 0.8, NS	NS, 0%	NS	Jadad scale 4/6 high quality
He et al, 2016[31]	10	597	β-Glucan 5 g	8	↓ 6.3, $P < .05$	$P < .001$, 98%		
Liu et al, 2016[33]	13	432	Fructans 13 g	7	↓ 0.7, NS	$P < .001$, 88%	$P < .05$	Cochrane 4/13 high quality

NS, not significant.

Two of the 3 meta-analyses that investigated β-glucan supplementation on changes in fasting insulin concentrations reported statistically significant reductions, with both of these meta-analyses reporting reductions of 6.3 pmol/L (Table 4). However, 1 of the 2 meta-analyses had statistically significant heterogeneity. The meta-analysis on fructan supplementation studies reported no statistically significant reduction in fasting insulin concentrations.

Five meta-analyses examined the effects of fiber supplementation on HbA1c, and all 5 assessed clinical studies that involved participants with type 2 diabetes (Table 5). The observed reductions in HbA1c for all 5 meta-analyses ranged between 0.21% and 0.52%, and 4 of the 5 meta-analyses reported that their differences were statistically significant. Only 1 of these 4 meta-analyses presenting with statistically significant changes in HbA1c had statistically significant heterogeneity.

Discussion

In this umbrella review, 3 meta-analyses presented with statistically significant findings ranging between a 15% to 19% reduction in the incidence of developing type 2 diabetes when comparing participants with the highest intakes of total dietary fiber to those with the lowest intakes (see Table 1).[17,19,21] Moreover, when total dietary fiber was separated into cereal, fruit, and vegetable fiber groups, it appeared that only cereal fiber significantly reduced the incidence of developing type 2 diabetes because a 17% to 33% statistically significant reduction was observed with all 4 meta-analyses that compared participants with the highest intakes of total cereal fiber to those with the lowest intakes.[17-19,21] However, we must appreciate these positive results with some caution because statistically significant heterogeneity was noted in all 3 meta-analyses on total dietary fiber, as well as all 4 meta-analyses on cereal fiber. Heterogeneity may be due to the wide variation in study design with differences in the number and characteristics of participants surveyed (such as age, sex, body mass index, total energy intake, and overall health status), as well as differences in the amounts and compositions of dietary fibers consumed and study duration.

If an increase in the consumption of cereal fibers can truly reduce the incidence of type 2 diabetes, the

Table 5. *Effects of Increased Fiber Intake on Changes in HbA1c%*

Meta-analysis Authors and Date	No. of Studies in Meta-analysis	No. of Participants in Meta-analysis	Fiber Type and Dose/Day	Mean Duration in Weeks	Reduction in HbA1c%	Q Test *P* Value and I^2 Statistic	Egger or Begg Test *P* Value	Quality Assessment and Outcome
Post et al, 2012[23 a]	10 T2D	324	Soluble 16 g	8	↓ 0.26, $P < .05$	NS, 21%		GRADE 9/10 high quality
Silva et al, 2013[24]	11 T2D	605	Soluble 15 g	11	↓ 0.52, $P < .05$	$P < .001$, 94%	NS	GRADE NR
Hou et al, 2015[29]	6 T2D	437	β-Glucan NR	4.5	↓ 0.42, $P < .001$	NS, 18%		NOS 5/6 high quality
Shen et al, 2016[30]	4 T2D	139	β-Glucan 3 g	4.5	↓ 0.21, $P < .05$	NS, 0%	NS	Cochrane 3/4 high quality
He et al, 2016[31]	4 T2D	229	β-Glucan 3.5 g	5.5	↓ 0.22, NS	$P < .001$, 92%		

HbA1c%, glycosylated hemoglobin percentage; *NOS*, Newcastle-Ottawa Scale; *NR,* not reported; *NS,* not significant; *T2D,* participants with type 2 diabetes only.

[a] Low-quality score on the Critical Appraisal Checklist for Systematic Review.

mechanism of action may be achieved through a reduction in both fasting blood glucose and insulin concentrations. This occurs because cereals made from oats and barley possess water-soluble gel-forming fibers such as β-glucan. These dietary fibers form a viscous solution in the small intestine, which reduces the contact and mixing of macronutrients with digestive enzymes, and this delays the absorption of glucose, which consequently reduces the postprandial plasma glucose and insulin levels.[60]

However, only 6 of the 11 meta-analyses on interventional fiber supplementation studies reported that increased dietary fiber was associated with a reduction in fasting blood glucose concentrations (see Table 2), and only 2 of the 4 meta-analyses on fasting insulin concentrations was associated with significant reductions (see Table 4).[23-33] Moreover, only 4 of the 7 meta-analyses analyzing interventional studies on β-glucan supplementation reported statistically significant reductions in fasting blood glucose, with reductions ranging widely between 2.3 to 44.6 mg/dL. It should be noted that 2 of these 4 meta-analyses used participants who had type 2 diabetes, whereas 3 of the 5 meta-analyses on participants without diabetes reported only small nonsignificant reductions in blood glucose concentrations. A similar finding was also noted with the only meta-analysis that looked at psyllium supplementation studies, which separated their studies by type 2 diabetic and nondiabetic participants.[32] Just as noted in the β-glucan meta-analyses, the psyllium supplementation meta-analysis on participants with type 2 diabetes reported significant reductions in fasting blood glucose concentrations of 37 mg/dL, but the participants without diabetes had nonsignificant reductions of only 1.6 mg/dL. Also, 1 of the 2 meta-analyses identifying significant reductions in fasting insulin concentrations analyzed studies that used only participants with type 2 diabetes.[26,31]

Based on these meta-analyses created from the dietary fiber interventional studies, it does not appear that the significant reductions in the incidence of type 2 diabetes noted with increased cereal fiber consumption are due to reductions in fasting blood glucose and insulin concentrations. Apart from soluble fibers like β-glucan, foods containing dietary fibers are also a rich source of magnesium. Magnesium is a co-factor for enzymes involved in glucose metabolism, such as tyrosine kinase, and it has been previously reported that there is an inverse association between dietary magnesium and the incidence of type 2 diabetes.[61] Also, dietary fiber intake has been reported to be inversely associated with inflammatory markers such as interleukin-6 and tumor necrosis factor α that are central in the initiation and progression of type 2 diabetes.[62]

Although the changes in fasting blood glucose concentrations may not explain the reductions reported in the incidence of type 2 diabetes in participants who increase their dietary fiber intake, these reductions may have significant benefits on reducing the negative consequences brought on by both microvascular and macrovascular changes in participants with type 2 diabetes. Measuring a patient's HbA1c is a good proxy measurement for assessing microvascular and macrovascular changes.[63-65] In this umbrella review, 4 of the 5 meta-analyses reported statistically significant reductions in HbA1c ranging between 0.21% and 0.52%, and more promising is the observation that only 1 of these 4 meta-analyses had statistically significant heterogeneity (see Table 5).[23,24,29-31] Although the percentage change in HbA1c is modest, it has potential to be clinically significant in light of the fact that the average change attributed to metformin ranges between 0.2% to 2%.[23] It must be recognized that this positive effect on HbA1c is modest compared with some of the changes noted in fasting blood glucose concentrations, and this may simply be attributed to the fact that the duration of these studies averaged only 4.5 to 8 weeks, which is less than the customary 12 week retesting period for HbA1c. HbA1c represents a weighted average of the blood glucose concentration because 50% of glycation occurs in days 90 to 120 of the red blood cell's 120-day average lifespan.[66] Although HbA1c is considered the standard measurement of long-term glycemic control, HbA1c tests may not be clinically reliable, especially for short-term outcomes, and should therefore be interpreted with caution.[67]

The Dietary Guidelines for Americans state that the adequate intake value of dietary fiber consumption is 25 to 38 g/day, but the 2009-2010 National Health and Nutrition Examination Survey indicated that the daily intake of fiber in the United States is only 17 g/day.[68] Therefore, emphasizing fiber consumption for health promotion and disease prevention is a critical public health goal, and by aggressively promoting the Dietary Guidelines for Americans recommendations of at least 25 to 38 g/day of total dietary fiber, this may prevent a significant number of new cases of type 2 diabetes. Although the evidence in this umbrella review supports the beneficial association of dietary fiber on reducing the incidence of type 2 diabetes, there are still too few long-term, large population, randomized controlled trials that have undertaken the goal to analyze this potential causal relationship between dietary fiber and type 2 diabetes. Also, evidence is lacking to recommend a higher dietary fiber intake for patients with diabetes than for the population as a whole. Finally, although no tolerable upper limit has been established for total fiber intake, it should be noted that minor side effects have been reported, such as flatulence, abdominal bloating, loose stools or diarrhea and abdominal cramping.[69]

Limitations

This umbrella review has several limitations that should be acknowledged. First, 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 physically active and avoiding smoking and excessive alcohol intake. Fortunately, the majority of studies included in the meta-analyses that were involved in this umbrella review did adjust for potential confounding factors, but the possibility of residual confounders cannot be excluded. Second, self-reported dietary fiber intake is most often assessed using food frequency questionnaires, and because these dietary assessment tools were not specifically developed for dietary fiber intake, misclassifications and measurement errors regarding fiber doses and types are quite likely. This problem may also be compounded by the fact that dietary fiber may be defined differently by the various food frequency questionnaire databases in use.[69] A third limitation is that the meta-analyses reviewed here represent a heterogeneous group of clinical studies composed from a diverse group of participants of different ages, sexes, races, and ethnic groups, and therefore readers are cautioned against specifying these results to any one specific sociodemographic group. Finally, as in all literature reviews, the quality of this umbrella review is directly related to the quality of the included meta-analyses, which are dependent on the design and reporting quality of the individual meta-analysis itself, as well as on the quality of the individual studies used to conduct the meta-analysis. Fortunately, the majority (94%) of the meta-analyses in this umbrella review were appraised as having moderate to high methodological quality.

Conclusion

This umbrella review suggests that there may be some evidence for dietary fiber intake, especially from cereal fibers, to be beneficial in the prevention of type 2 diabetes; however, these results should be considered with caution because of the statistically significant heterogeneity. There also appears to be a small reduction in fasting blood glucose concentration, as well as a small reduction in HbA1c percentage, for individuals with type 2 diabetes who add β-glucan or psyllium to their daily dietary intake. Therefore, people with type 2 diabetes should be encouraged to increase their dietary intake of foods that are rich in fiber, such as high-fiber cereals, or to use fiber supplements. Further studies using large multicenter randomized controlled trials are required to confirm these findings, and more studies evaluating HbA1c for durations of longer than 12 weeks are warranted. Moreover, future studies are required to explore the underlying mechanisms responsible for the relationship between dietary fiber intake and the reduction in the incidence of type 2 diabetes.

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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

- Dietary fiber consumption has been postulated to reduce the incidence of type 2 diabetes and the risk of microvascular and macrovascular complications in those with type 2 diabetes.
- There is much discrepancy when it comes to randomized controlled studies on dietary fiber's effects on these important clinical conditions.
- By combining the meta-analyses on these clinical outcomes as an umbrella review, we can determine that increased dietary fiber intake may help reduce the incidence of type 2 diabetes, as well as reduce both fasting blood glucose concentrations and glycosylated hemoglobin percentages in people with type 2 diabetes.

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