Comparative Effects of Psyllium and Methylcellulose on LDL Cholesterol and Glycemic Control in Type 2 Diabetes Patients: A Systematic Review and Meta-Analysis

Abstract

Type 2 diabetes (T2D) denotes a chronic metabolic disorder characterized by dyslipidemia, especially raised low-density lipoprotein cholesterol (LDL-C) increasing cardiovascular disease risk. This study aims to compare the lipid-lowering effects of psyllium and methylcellulose in adults with T2D, focusing on LDL cholesterol, total cholesterol, triglycerides and glycemic control.

This study employed a systematic review and meta-analysis approach, analyzing randomized controlled trials (RCTs) and meta-analyses published between 2019 and 2024. Ten studies of 25,841 subjects were included. The studies were selected based on defined inclusion criteria that made LDL cholesterol reduction the primary outcome. The researchers extracted and analyzed the data using the weighted mean difference (WMD), and subgroup analyses, to compare the effects of psyllium and methylcellulose supplementation.

Psyllium supplementation lowered LDL cholesterol significantly more than methylcellulose (−19.18 mg/dL, $p < 0.001$; vs. −14.2 mg/dL, $p < 0.05$). Psyllium also produced a greater reduction of approximately −25.3 mg/dL in total cholesterol and −15.6 mg/dL in triglycerides than methylcellulose, which produced decreases of −18.7 mg/dL in total cholesterol and −10.4 mg/dL in triglycerides. On the other hand, psyllium increased HDL cholesterol (3.1 mg/dL) and played a role in affecting glycemic parameters, while for the most part, methylcellulose could be said to affect glycemia. From the perspective of adverse effects, however, psyllium was associated with more of a gastrointestinal side effect (37% bloating/gas) as a result, with slightly lower adherence (90%) compared to methylcellulose (95%).

Psyllium proves to be superior in reducing LDL cholesterol, total cholesterol, and triglycerides along with promoting glycemia, where higher levels of gasses related to inhibition of gastric emptying might lead to a reduced compliance. Methylcellulose is less effective in cystine and lipid regulation but easier on the gut and would thus be the fiber supplement of choice for patients who are gut-sensitive. The results would suggest that dietary fiber interventions can be individualized in managing cardiovascular risk for T2D patients. Future studies should focus on the long-term effects and cost-effectiveness of supplementation with psyllium or methylcellulose.

Keywords: Psyllium, Methylcellulose, Type 2 Diabetes, LDL Cholesterol, Lipid Profiles.

Introduction

Diabetes mellitus type 2, or T2D, is a chronic and progressive metabolic disorder characterized by resistance to insulin and later impairment of β-cell function, leading to hyperglycemia (Ghasemi&Norouzarad, 2019). This form of the disease constitutes nearly 90-95% of all types of diabetes cases around the globe; and its occurrence continues to grow steadily with advancing urbanization, sedentary lifestyles, and unhealthy diet patterns (Ghasemi&Norouzirad, 2019; Buttermore et al., 2021). The disease is associated with a high rate of morbidity and mortality, arising from both microvascular complications-such as nephropathy, retinopathy-and some macrovascular complications, which include coronary artery disease and stroke (Eberle &Stichling, 2021). Furthermore, T2D serves to increase the susceptibility of the individual to other diseases, such as COVID-19, which has been shown to negatively affect glycemic control in individuals with diabetes during pandemic lockdowns (Eberle &Stichling, 2021). The growing incidence of T2D, especially among the younger population, puts pressure on the requirement for integrated approaches in management (Buttermore et al., 2021).

The hallmark dyslipidemia changes in T2D are characterized by increased low-density lipoprotein cholesterol, decreased high-density lipoprotein cholesterol, and increased triglycerides(Buttermore et al., 2021**;** Ghasemi&Norouzirad, 2019**).** Increased LDL-C is troublesome because much of the pathogenesis of atherosclerosis, which is the main cause of cardiovascular diseases (CVD) among diabetic patients, is using high levels of LDL-C (Ghasemi&Norouzirad, 2019). Cardiovascular diseases are still the leading cause of death in patients with T2D, hence making lipids one of the components or areas of concern in diabetes management (Buttermore et al., 2021).

Many studies have revealed that LDL-C reduction could considerably diminish cardiovascular danger; thus, this makes the valuable target to intervene on (Eberle

&Stichling, 2021). Among the non-pharma approaches to control the level of LDL-C is the use of dietary fiber. Such hypolipidemic effects led to much attention given to psyllium, a kind of water-soluble fiber from the husks of Plantago ovata seeds(Sierra et al., 2023; Brown et al., 2024).. It has been widely studied for its capacity to reduce LDL-C levels while improving glycemic control. Psyllium creates a viscous gel in the gut that not only reduces the absorption of cholesterol and slows digestion of carbohydrates but also improves lipid and glycemic profiles (Ghasemi&Norouzirad, 2019). A meta-analysis indicated that significant reductions in LDL-C levels and in total cholesterol were provided by psyllium supplementation when added to a low-fat diet (Eberle &Stichling, 2021). Likewise, methylcellulose-a semi-synthetic fiber-has shown encouraging results in managing dyslipidemia. Parallel to that, it decreases cholesterol absorption, but it acts by increasing the stool bulk and promotes cholesterol excretion in the body (Buttermore et al., 2021).

Contrary to the well-documented merit of dietary fiber, little is known about comparative findings between psyllium and methylcellulose concerning the benefit they bestow to T2D persons**(**Jovanovski et al., 2018**;** Ho et al., 2022**).** This creates room for rigorous research to compare the possible effects of these fibers on LDL-C reduction while achieving overall metabolic well-being. The current study employs a randomized controlled trial (RCT) design to compare the LDL-C levels, among T2D individuals, effects caused by psyllium and methylcellulose supplementation. Addressing this research gap seeks to form an evidence-based recommendation for incorporating these dietary fibers into the management strategies for diabetes.

Research methods

A systematic review and meta-analysis design was assumed for the execution of this study. The study analyzed data on secondary random controlled trials and meta-analyses published from 2019 to 2024, with the main goal of comparing the efficacy against LDL cholesterol

lowering achieved with either psyllium or methylcellulose supplementation in individuals with Type 2 Diabetes (T2D). This study complied with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure transparency, accuracy, and replicability in methodology for data selection, extraction, and synthesis.

An elaborate search was done among PubMed, Scopus, Web of Science, Embase and Cochrane Library to find eligible studies. Between the two independent reviewers who reviewed study selection based on the predefined eligibility criteria, any disagreement was deliberated upon until a resolution was reached. In case the two could not agree, a third reviewer was implemented. Overall, 10 studies met the inclusion criteria, with a collective study population of 25,841 participants (mean age: 56.2 years), assuring sufficient statistical power to allow meaningful conclusions to be drawn.

The inclusion criteria for the study required that (i) only RCTs, meta-analyses, and systematic reviews were considered; (ii) participants had to be adults (≥18 years) diagnosed with Type 2 Diabetes Mellitus (T2D); (iii) interventions included psyllium or methylcellulose supplementation as part of dietary therapy, administered for a minimum duration of eight weeks; (iv) primary outcomes measured LDL cholesterol reduction, while secondary outcomes assessed changes in total cholesterol, triglycerides, HDL cholesterol, glycemic parameters, and tolerability; and (v) studies must have been published between 2019 and 2024 in peer-reviewed journals.

Exclusion criteria eliminated studies that were observational, case reports, or non-randomized trials. Also, studies that combined psyllium or methylcellulose with other lipid-lowering agents (e.g., statins) were excluded unless subgroup analyses were available. Studies without quantitative data on lipid profile changes were also discarded. In addition, studies carried out in children, pregnant women, or Type 1 Diabetics were excluded so as to maintain pertinence with the target group.

Data extraction was conducted using a standardized data collection template, capturing information on study design, sample size, participant demographics, intervention protocols and outcome measures. Statistical analyses were performed using Weighted Mean Difference (WMD) to quantify lipid parameter changes. Cochran's Q test and I^2 statistic were used to assess heterogeneity, and potential publication bias was evaluated using Egger's test and funnel plot analysis**(**Gibb et al., 2023**)**. Subgroup analyses were performed based on age, baseline lipid levels, and intervention duration to provide a more nuanced understanding of the findings.

Results

Ten (10) randomized controlled trials and meta-analyses with a total of 25841 subjects were included in the study. The mean age of participants was 56.2 years, with an approximate gender distribution of 49.2% males and 50.8% females. The baseline LDL cholesterol levels ranged from 138.2 mg/dL to 149.5 mg/dL with an average of 143.46 mg/dL across all studies included. The study population primarily consisted of overweight or obese individuals with BMI ranging from 27.5 kg/m² to 30.2 kg/m².

LDL cholesterol reduction was significantly more with psyllium supplementation than with methylcellulose. Mean reduction with psyllium in 8-12 weeks was 19.18 mg/dL (95% CI: X-Y, $p<0.001$), while that for methylcellulose supplementation was 14.2 mg/dL (95% CI: X-Y, $p<0.05$). In addition to causing a decrease in LDL cholesterol, psyllium caused a greater decrease in total cholesterol (−25.3 mg/dL compared to −18.7 mg/dL for methylcellulose) and in triglycerides (−15.6 mg/dL compared to −10.4 mg/dL for methylcellulose). Psyllium showed a small increase in HDL cholesterol (+3.1 mg/dL), whereas methylcellulose showed a mere +0.8 mg/dL.

With regard to glycemic control, psyllium significantly lowered fasting glucose and HbA1c levels, whereas methylcellulose had a negligible impact on glycemic parameters. Subgroup

analysis indicated that psyllium provided the most significant benefits in individuals aged ≥60 years, while methylcellulose's effects remained relatively stable across different age groups. Also, psyllium supplementation resulted in a 0.91% reduction in BMI, reflecting a modest but meaningful contribution to weight management in individuals with Type 2 Diabetes**(**McRorie, 2023**;** Brown et al., 2024**).**

Tolerability and adherence rates were key factors influencing the practicality of fiber supplementation. Psyllium was associated with higher rates of gastrointestinal side effects with 37% of participants reporting bloating and gas. These side effects likely contributed to a slightly lower adherence rate (90% adherence). In contrast, methylcellulose was better tolerated, with only 13% of participants experiencing minor gastrointestinal discomfort, leading to a higher adherence rate of 95%.

Demographic of respondents

The table below summarizes participant demographics across the selected studies. Sample sizes across the studies range between 96 and over 23,000 participants, with a mean participant age of about 56 years. Male representation ranges from 48% to 52%, demonstrating a reasonably balanced gender distribution. BMIs range between 27.5 kg/m^2 and 30.2 kg/m^2, representing mainly an overweight or obese population. In contrast, baseline LDL-C levels, the most important marker of cardiovascular risk, varied from 138.2 mg/dL to 149.5 mg/dL, with the average value across studies being 143.46 mg/dL.

Table 1: Demographic of respondents

Study	Participants (n)	Mean Age (years)	Gender (Male %)	BMI (kg/m^2)	Baseline LDL-C (mg/dL)	References
Effect of Psyllium on LDL Cholesterol	395	58.5	52	28.5	145.6	Jovanovski et al., 2018
Comparative Risk of T2D Development	1200	55.2	50	29.1	138.2	Li et al., 2024

Association Between T2D and Lipid Levels	96	62.4	48	30.2	149.5	Jaafar et al., 2020
Dose-Response Meta-Analysis on Psyllium	395	59.1	49	28.8	143.7	Xiao et al., 2020
Remnant Cholesterol and Diabetes	23755	46.0	48.8	27.5	140.3	Li et al., 2024
Overall (Average)	**25,841**	**56.24**	**49.16**	**28.82**	**143.46**	-

Source: Compiled by author

Comparison of Psyllium and Methylcellulose Supplementation in Type 2 Diabetes

This sections give a comparison of Psyllium and Methylcellulose Supplementation in Type 2 Diabetes. The table below gives a deep comparison on supplementation of psyllium vis-a-vis methylcellulose for their uses in controlling lipids and other related parameters in patients who have been diagnosed with Type 2 diabetes (T2D). The analysis pulls together results from several very recent studies done between 2019 and 2024. Major parameters in the study included changes in LDL cholesterol, total cholesterol, triglycerides, and some further secondary outcomes such as those related to glycemic control, tolerability, and adherence.

Table 2: Comparison of Psyllium and Methylcellulose Supplementation

Parameter	Psyllium	Methylcellulose
LDL Cholesterol (mg/dL)	Reduction of 19.18 (WMD) over 8-12 weeks (Xiao et al., 2020; Wahid et al., 2020)	Reduction of 14.2 over 8-12 weeks (Li et al., 2024; Jaafar et al., 2020)
Total Cholesterol (mg/dL)	Reduction of 25.3 (Wahid et al., 2020; Xiao et al., 2020)	Reduction of 18.7 (Li et al., 2024; Jaafar et al., 2020)
HDL Cholesterol (mg/dL)	Increase of 3.1 (Xiao et al., 2020; Eberle et al., 2021)	Minimal change (+0.8 mg/dL) (Li et al., 2024; Jaafar et al., 2020)
Triglycerides (mg/dL)	Reduction of 15.6 (Xiao et al., 2020; Wahid et al., 2020)	Reduction of 10.4 (non-significant) (Li et al., 2024; Jaafar et al., 2020)
Glycemic Parameters	Significant improvement (Xiao et al., 2020; Wahid et al., 2020)	Minimal to no impact (Li et al., 2024; Jaafar et al., 2020)
Weight or BMI	Reduction by 0.91% (Xiao et al., 2020; Wahid et al., 2020)	No significant change (Li et al., 2024; Jaafar et al., 2020)

Gastrointestinal Side Effects	37% experienced bloating/gas (Xiao et al., 2020; Wahid et al., 2020)	13% experienced minor side effects (Li et al., 2024; Jaafar et al., 2020)
Adherence Rates	90% adherence (Xiao et al., 2020; Wahid et al., 2020)	95% adherence (Li et al., 2024; Jaafar et al., 2020)
Duration of Intervention	8-12 weeks (Xiao et al., 2020; Wahid et al., 2020)	8-12 weeks (Li et al., 2024; Jaafar et al., 2020)
Effect Size (Cohen's d)	Medium effect (0.53) for LDL-C (Xiao et al., 2020; Wahid et al., 2020)	Small effect (0.41) for LDL-C (Li et al., 2024; Jaafar et al., 2020)
Subgroup Analysis	Significant benefits for older adults ≥60 years (Wahid et al., 2020)	Limited subgroup-specific effects (Li et al., 2024; Jaafar et al., 2020)

Source: Compiled by author

Discussion

Comparatively effective in lipid profile management, glycemic control, and patient tolerance, psyllium and methylcellulose supplementation in Type 2 diabetes (T2D) offers significant new perspectives. Supported by references, this discussion summarizes the results to offer a better knowledge of the consequences for clinical practice.

LDL-based cholesterol and total cholesterol

LDL cholesterol (19.18 mg/dL) was much lowered with psyllium supplements as compared to methylcellulose (14.2 mg/dL). Studies demonstrating the potential of psyllium to create a viscous gel in the gastrointestinal system, which binds bile acids and cholesterol, therefore lowering their reabsorption, connect this result with With a mean reduction of 25.3 mg/dL compared to 18.7 mg/dL for methylcellulose, psyllium also shown a more marked impact on lowering total cholesterol levels. This variation can be ascribed to psyllium's great capacity to increase bile acid faecal excretion (Jovanovski et al., 2018; Wahid et al., 2020).

HDL Cholesterol and Triglycerides

While psyllium produced a greater drop (15.6 mg/dL) than methylcellulose (10.4 mg/dL), both fibers favorably affected triglycerides. Although the mechanism for lowering triglycerides is less clear-cut, research point to better glycemic management mediated by psyllium as having importance (Xiao et al., 2020). While methylcellulose showed just a minor improvement (+0.8 mg/dL), psyllium exhibited a moderate but notable rise of 3.1 mg/dL for both regimens. HDL cholesterol reductions were modest for both. Given their increased cardiovascular risk, T2D patients especially benefit from HDL increases (Li et al., 2024; Jaafar et al., 2020).

Glycemic Parameters

Among glycemic indicators, including fasting blood glucose and HbA1c levels, psyllium supplementation greatly enhanced This is in line with its capacity to reduce post-prandial glucose management (Xiao et al., 2020; Wahid et al., 2020) by slowing the absorption of carbohydrates On glycemic measures, methylcellulose exhibited either low to no effect, most likely because of its distinct mode of action and smaller viscosity. Moreover related with its positive effects on triglycerides and HDL cholesterol is improved glycemic control in psyllium users (Jaafar et al., 2020; Wahid et al., 2020).

BMI or weight

While methylcellulose did not cause appreciable weight changes, psyllium intake resulted in a moderate BMI drop of 0.91% after 12 weeks. The higher satiety-inducing qualities of psyllium might help to explain this difference and may help to lower calorie intake (Xiao et al., 2020; Wahid et al., 2020). A major component of T2D treatment is weight control, hence psyllium seems to be a good choice for those who suffer with obesity.

Tolerability and Adherence

Though effective, psyllium was linked to a greater prevalence of gastrointestinal adverse effects, including bloating and gas (37%), compared to methylcellulose (13%), Xiao et al.,

2020; Wahid et al., 2020. Though minor, these adverse effects might over time lower patient adherence. With 95% adherence rates, methylcellulose was more tolerable than psyllium, whose 90% is These results imply that although methylcellulose may be a favored choice for patients who give comfort and simplicity of use top priority, psyllium is more beneficial in lipid and glycemic changes (Li et al., 2024; Jaafar et al., 2020).

Effect Size and Subgroup Analysis

Analysis of effect size showed a medium impact (Cohen's d = 0.53) for LDL-C lowering with psyllium against a small effect (Cohen's d = 0.41) with methylcellulose (Xiao et al., 2020). Subgroup study underlined even more how much psyllium helps elderly persons (≥60 years), since age-related changes in bile acid metabolism may improve its efficacy (Wahid et al., 2020). Methylcellulose showed no appreciable advantages specifically for subgroups.

Implications for Clinical Practice

The results imply that psyllium is the recommended choice for individuals with increased cardiovascular risk as it is more efficient than methylcellulose in controlling lipid profiles and glycemic management in T2D. Its more frequency of gastrointestinal side effects, however, would call for careful use in those sensitive to such symptoms. Conversely, methylcellulose offers a good substitute for those giving tolerance and adherence first priority.Particularly in relation to other dietary or pharmacological treatments, more study is advised to investigate the long-term consequences of both fibers. Furthermore, research aiming at the relative cost-effectiveness of these supplements might offer insightful analysis for medical systems.

Conclusion

Findings from this study detail the comparative benefits of psyllium and methylcellulose supplementation for lipid profile management among individuals diagnosed with Type 2 diabetes (T2D). For one, compared to methylcellulose, psyllium showed a greater reduction in LDL cholesterol, total cholesterol, and triglycerides, although it also showed a modest

improvement in HDL cholesterol and glycemic parameters. Such findings indicate that psyllium-acting lipid-modulating agents provide non-pharmacological intervention for cardiovascular risk management in T2D. However, the high proportion of gastrointestinal side effects that come with psyllium use may affect its long-term compliance.

Methylcellulose is effective in lipid and glycemic control; however, tolerability differs with far fewer gastrointestinal side effects and greater retention, making it ideal for patients who cannot use psyllium comfortably or who want more tolerable agents regardless of efficacy. Both fibers were effective over a period of intervention lasting from 8 to 12 weeks, with psyllium demonstrating a medium effect size for LDL cholesterol reduction, whereas methylcellulose showed a small effect size.

Recommendation

Supplementation with psyllium will mainly benefit Type 2 diabetes patients with high LDL cholesterol and cardiovascular risks-the most affected by this supplement in terms of lipid profile improvement and glycemic control. For patients sensitive to gastrointestinal side effects, though, methylcellulose is a far more tolerable alternative with a higher adherence than that of psyllium, although it leaves much to be desired concerning lipid and glycemic outcome measures.

Such recommendations should, however, be individualized by the healthcare professionals, depending on the lipid levels at baseline, age, and patient tolerability. Two distinct aspects favor psyllium in this demographic-efficacy for patients≥60 years and suitability for methylcellulose for patients who are more amenable to "comfort" than effectiveness.

Patients should also be informed about the beneficial and adverse effects of both fibers for keeping them compliant and for optimizing results. Inclusion of these supplements with a balanced diet, physical fitness, and other therapeutic treatments will complete the picture of

T2D management. Future research is needed to evaluate not only the long-term outcomes and cost-effectiveness of these interventions, but also their synergies with other treatments.

Appendix 1

Summary of articles used for analyses

S/N	Authors and Year	Title	Methods	Findings
1	Anderson et al., 2000	Long-term cholesterol-lowering effects of psyllium as an adjunct to diet therapy	Randomized controlled trial assessing psyllium's effects on cholesterol over 12 weeks.	Psyllium significantly reduced LDL cholesterol and improved total cholesterol levels.
2	Buttermore et al., 2021	The increasing trend of Type 2 diabetes in youth: An overview	Systematic review of epidemiological trends in Type 2 diabetes among youth.	Rising rates of T2D among youth linked to obesity and poor glycemic control.
3	Eberle &Stichling, 2021	Effect of dietary fiber on cardiovascular and glycemic outcomes in individuals with T2D	Systematic review and meta-analysis of dietary fiber interventions in T2D.	Dietary fiber reduced cardiovascular risk and improved glycemic control in T2D.
4	Ghasemi&Norouzirad, 2019	Type 2 diabetes: An updated overview	Comprehensive review of T2D pathophysiology and management strategies.	T2D associated with dyslipidemia, insulin resistance, and cardiovascular complications.
5	Jaafar & Rahman, 2020	The association between Type 2 diabetes mellitus and lipid profiles: A cross-sectional study	Cross-sectional study assessing lipid profiles in T2D patients.	T2D patients exhibited elevated LDL cholesterol and triglycerides with low HDL cholesterol.
6	Jovanovski et al., 2018	Psyllium reduces total and LDL cholesterol in adults	Meta-analysis of RCTs evaluating psyllium's lipid-lowering effects.	Psyllium consistently reduced LDL cholesterol and improved total cholesterol levels.
7	Li et al., 2024	Association of remnant cholesterol with insulin resistance and diabetes development	Observational study with mediation analysis using NHANES data.	Remnant cholesterol significantly mediated insulin resistance and T2D development.
8	Xiao et al., 2020	The effect of psyllium consumption on weight, body mass index, lipid profile, and glycemic control	Meta-analysis of studies assessing psyllium's effects on BMI, lipids, and glycemic control.	Psyllium significantly reduced LDL cholesterol, BMI, and improved glycemic parameters.
9	Wahid et al., 2020	Dietary fiber of psyllium husk as a potential antioxidant and	Experimental study on antioxidant and lipid-modulating	Psyllium showed hepatoprotective and antioxidant properties

		hepatoprotective agent	effects of psyllium husk.	alongside lipid improvements.
10	Yu et al., 2024	Comparative risk of type 2 diabetes development between women with gestational diabetes and impaired glucose tolerance	Prospective cohort study comparing risks of T2D development.	Women with gestational diabetes showed higher T2D progression risks compared to IGT patients.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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