



A PROSPECTIVE INTERVENTIONAL STUDY TO EVALUATE THE ROLE OF DIETARY FIBER AND WHOLE GRAINS IN REDUCING THE DIABETES RISK

Prabhavathi Kotni^{*1}, Amarnath B R², Akash Vishwe³

^{1*} Assistant Professor, Department of Pharmacology, Index Medical College, Hospital and Research Centre, Indore, Madhya Pradesh, India

² Assistant Professor, Department of Pharmacology, Index Medical College, Hospital and Research Centre, Indore, Madhya Pradesh, India

³ Assistant Professor, Department of Pharmacology, Index Medical College, Hospital and Research Centre, Indore, Madhya Pradesh, India

***Corresponding Author: Prabhavathi Kotni**

*Email: prabhavathi2882@gmail.com

Abstract

Background: Type 2 diabetes mellitus represents a growing global health burden. Dietary modification, particularly increased consumption of dietary fiber and whole grains, may play a crucial role in diabetes prevention among high-risk individuals.

Objective: This prospective interventional study aimed to evaluate the effect of a high-fiber, whole grain-enriched diet on glycemic parameters and diabetes risk markers in prediabetic individuals over a 6-month period.

Methods: One hundred fifty participants with prediabetes were randomly allocated to either an intervention group (n=75) receiving a structured high-fiber, whole grain-enriched dietary plan (≥ 35 g fiber/day) or a control group (n=75) following standard dietary recommendations. Primary outcomes included changes in fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), and homeostatic model assessment of insulin resistance (HOMA-IR). Secondary outcomes comprised anthropometric measurements, lipid profile, and inflammatory markers.

Results: At 6 months, the intervention group demonstrated significantly greater reductions in FPG compared to controls (14.8 ± 6.2 mg/dL vs 6.1 ± 5.4 mg/dL, $p < 0.001$). HbA1c decreased more substantially in the intervention group ($0.48 \pm 0.22\%$ vs $0.18 \pm 0.19\%$, $p < 0.001$). HOMA-IR reduction was also superior in the intervention group (0.92 ± 0.48 vs 0.34 ± 0.41 , $p < 0.001$). The intervention group achieved greater weight loss (4.6 ± 2.1 kg vs 1.8 ± 1.9 kg, $p < 0.001$) and improved lipid profiles. Diabetes incidence was significantly lower in the intervention group (4.0% vs 14.7%, $p = 0.021$).

Conclusion: A structured high-fiber, whole grain-enriched diet significantly improves glycemic control, insulin sensitivity, and metabolic parameters in prediabetic individuals, demonstrating potential as an effective dietary intervention for diabetes prevention.

Keywords: Type 2 diabetes mellitus; dietary fiber; whole grains; prediabetes; glycemic control; insulin resistance; diabetes prevention.

Introduction

Type 2 diabetes mellitus has emerged as one of the most pressing public health challenges of the 21st century, affecting approximately 463 million adults worldwide, with projections suggesting this number will rise to 700 million by 2045 [1]. The disease imposes substantial economic burden and is associated with significant morbidity and mortality due to microvascular and macrovascular complications [2]. Given the escalating prevalence and the substantial proportion of cases attributable to modifiable lifestyle factors, identification of effective preventive strategies represents a critical public health priority.

Prediabetes, characterized by impaired fasting glucose or impaired glucose tolerance, affects an estimated 374 million individuals globally and confers high risk for progression to overt diabetes, with annual conversion rates ranging from 5% to 10% [3]. However, this intermediate hyperglycemic state presents a window of opportunity for intervention to prevent or delay diabetes onset. Landmark diabetes prevention trials have demonstrated that lifestyle modifications, particularly dietary changes and physical activity, can reduce diabetes incidence by 40% to 60% in high-risk populations [4].

Dietary composition plays a fundamental role in glucose homeostasis and insulin sensitivity. Emerging evidence suggests that dietary fiber intake and consumption of whole grains exert favorable effects on glycemic control through multiple mechanisms, including delayed gastric emptying, reduced postprandial glucose excursion, improved insulin sensitivity, and modulation of gut microbiota [5]. Observational epidemiological studies have consistently demonstrated inverse associations between whole grain consumption and diabetes risk, with meta-analyses showing a 20% to 30% risk reduction in individuals with highest versus lowest intake [6].

The biological mechanisms underlying the protective effects of dietary fiber are multifaceted. Soluble fiber forms viscous gels in the gastrointestinal tract, slowing nutrient absorption and attenuating postprandial glycemic responses [7]. Insoluble fiber, abundant in whole grains, enhances insulin sensitivity through effects on gut hormone secretion, including glucagon-like peptide-1 (GLP-1) and peptide YY [8]. Furthermore, fiber fermentation by colonic microbiota produces short-chain fatty acids that modulate glucose metabolism and inflammatory pathways [9].

Despite robust observational evidence, interventional trials examining the effects of structured high-fiber, whole grain-enriched diets on diabetes prevention in prediabetic populations remain limited. Most previous studies have evaluated fiber supplementation rather than food-based approaches, examined short-term glycemic effects rather than sustained metabolic improvements, or included heterogeneous populations without specific focus on high-risk individuals [10]. Furthermore, current dietary guidelines for diabetes prevention vary in their specific recommendations regarding optimal fiber intake levels and whole grain portions [11].

The identification of practical, sustainable dietary interventions that can be implemented at the population level is essential for translating scientific evidence into effective diabetes prevention programs. Food-based approaches emphasizing whole grains offer practical advantages over isolated fiber supplements, providing additional nutrients, phytochemicals, and bioactive compounds that may contribute synergistically to metabolic health [12].

Given these considerations, we conducted a prospective interventional study to evaluate the efficacy of a structured high-fiber, whole grain-enriched dietary intervention on glycemic parameters, insulin resistance, anthropometric measures, and diabetes incidence in individuals with prediabetes. We hypothesized that a dietary pattern emphasizing increased fiber and whole grain consumption would produce superior improvements in metabolic outcomes compared to standard dietary recommendations, thereby reducing progression to type 2 diabetes.

Materials and Methods

Study Design and Setting

This was a prospective, randomized, controlled interventional study conducted at the Department of Endocrinology, Index Medical College, Hospital and Research Centre between June 2017 and October 2018. The study protocol was approved by the Institutional Ethics Committee, and written

informed consent was obtained from all participants prior to enrolment.

Sample Size Calculation

Sample size estimation was based on anticipated differences in fasting plasma glucose reduction between groups. Assuming a mean difference of 8 mg/dL with a standard deviation of 12 mg/dL, alpha error of 0.05, and power of 85%, the required sample size was calculated as 68 participants per group. Accounting for an anticipated dropout rate of 10%, we aimed to recruit 75 participants per group, totaling 150 participants.

Participant Selection

Inclusion Criteria:

- Age 25-65 years
- Diagnosed prediabetes according to American Diabetes Association criteria: fasting plasma glucose 100-125 mg/dL and/or HbA1c 5.7-6.4%
- Body mass index (BMI) 23-35 kg/m²
- Willingness to adhere to dietary intervention and attend follow-up visits
- Stable body weight (variation <3 kg) in the preceding 3 months

Exclusion Criteria:

- Established type 2 diabetes mellitus or use of antidiabetic medications
- Chronic gastrointestinal disorders (inflammatory bowel disease, celiac disease, malabsorption syndromes)
- Severe renal impairment (estimated glomerular filtration rate <30 mL/min/1.73m²)
- Severe hepatic dysfunction
- Current use of medications affecting glucose metabolism (corticosteroids, atypical antipsychotics)
- Pregnancy or lactation
- Active malignancy
- Participation in other dietary intervention studies within the previous 6 months

Randomization and Allocation

Eligible participants were randomized in a 1:1 ratio using computer-generated random number sequences in sealed opaque envelopes. Randomization was stratified by age (<45 years vs ≥45 years) and BMI (<28 kg/m² vs ≥28 kg/m²) to ensure balanced distribution of key prognostic factors. Allocation was performed by an independent research coordinator not involved in participant assessment or dietary counselling.

Intervention Protocol

Intervention Group (n=75): Participants received individualized dietary counselling from a registered dietitian to implement a high-fiber, whole grain-enriched diet targeting ≥35 g total dietary fiber per day, with emphasis on whole grain products (≥3 servings/day). The dietary plan emphasized:

- Replacement of refined grains with whole grain alternatives (brown rice, whole wheat bread, oats, barley, quinoa)
- Increased consumption of legumes (at least 4 servings/week)
- Daily intake of vegetables (≥5 servings) and fruits (≥2 servings)
- Incorporation of nuts and seeds (28 g/day)
- Limitation of simple sugars and processed foods

Total energy intake was designed to achieve a 500 kcal/day deficit for participants with BMI ≥25 kg/m². Macronutrient distribution targeted 50-55% carbohydrates, 25-30% fat, and 15-20% protein.

Control Group (n=75): Participants received general dietary advice consistent with standard diabetes prevention recommendations, including balanced macronutrient distribution, portion

control, and reduced intake of refined sugars and saturated fats. No specific fiber targets or whole grain requirements were prescribed. Energy restriction was similar to the intervention group. Both groups received dietary counselling at baseline, with reinforcement sessions at weeks 2, 4, 8, 12, 16, and 20. Participants completed 3-day food records monthly, which were analyzed using nutritional software to assess dietary compliance.

Outcome Measures

Primary Outcomes:

- Change in fasting plasma glucose (FPG) from baseline to 6 months
- Change in glycated hemoglobin (HbA1c) from baseline to 6 months
- Change in homeostatic model assessment of insulin resistance (HOMA-IR) from baseline to 6 months

Secondary Outcomes:

- Anthropometric measurements: body weight, BMI, waist circumference
- Lipid profile: total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides
- Inflammatory markers: high-sensitivity C-reactive protein (hs-CRP)
- Incidence of type 2 diabetes during the study period

Assessments and Measurements

Assessments were conducted at baseline, 3 months, and 6 months by trained research personnel blinded to group allocation.

Anthropometric Measurements: Body weight was measured using a calibrated digital scale with participants wearing light clothing. Height was measured using a wall-mounted stadiometer. Waist circumference was measured at the midpoint between the lower costal margin and iliac crest using a non-stretchable measuring tape.

Biochemical Assessments: Venous blood samples were collected after 10-12 hours overnight fasting. FPG was measured using the glucose oxidase method. HbA1c was determined by high-performance liquid chromatography. Fasting insulin was measured using chemiluminescence immunoassay. HOMA-IR was calculated as: $[\text{fasting insulin } (\mu\text{U/mL}) \times \text{fasting glucose (mg/dL)}] / 405$. Lipid profile and hs-CRP were measured using standard enzymatic methods.

Dietary Assessment: Three-day food records (including two weekdays and one weekend day) were collected monthly. Dietary fiber intake was calculated using nutrient analysis software. Whole grain servings were quantified based on defined portion sizes.

Diabetes Diagnosis

Participants meeting American Diabetes Association criteria for diabetes (fasting plasma glucose ≥ 126 mg/dL or HbA1c $\geq 6.5\%$ on two separate occasions) during the study period were classified as incident diabetes cases and referred for standard care.

Statistical Analysis

Data were analyzed using SPSS version 24.0 software. Continuous variables were expressed as mean $\pm$ standard deviation (SD) and categorical variables as frequencies and percentages. Normality of distribution was assessed using the Kolmogorov-Smirnov test. Baseline characteristics were compared using independent t-tests for continuous variables and chi-square tests for categorical variables.

Primary analysis utilized repeated measures ANOVA to compare changes in glycemic parameters between groups over time, with baseline values as covariates. Between-group differences at 6 months were assessed using independent t-tests. Achievement of diabetes diagnosis was compared using chi-square test. Subgroup analyses were performed stratified by baseline BMI and age categories. A p-value < 0.05 was considered statistically significant. Analysis was conducted on an intention-to-treat

basis, with last observation carried forward for missing data.

Study Results

Participant Flow and Baseline Characteristics

A total of 198 individuals with prediabetes were screened for eligibility. Of these, 48 did not meet inclusion criteria or declined participation. One hundred fifty participants were randomized, with 75 allocated to each group. During the 6-month study period, 8 participants in the intervention group and 7 participants in the control group were lost to follow-up or withdrew consent. The final analysis included 135 participants (67 in intervention group, 68 in control group) who completed the study protocol.

Baseline demographic, anthropometric, and metabolic characteristics were well-balanced between groups (Table 1). The mean age was 49.6 ± 9.8 years in the intervention group and 50.2 ± 10.4 years in the control group. Both groups had similar gender distribution, BMI, waist circumference, and baseline glycemic parameters.

Table 1: Baseline Characteristics of Study Participants

Characteristics	Intervention Group (n=75)	Control Group (n=75)	p-value
Age (years)	49.6 ± 9.8	50.2 ± 10.4	0.714
Males, n (%)	38 (50.7)	36 (48.0)	0.742
Females, n (%)	37 (49.3)	39 (52.0)	0.658
Body weight (kg)	76.4 ± 12.6	75.8 ± 13.2	0.781
Body Mass Index (kg/m ²)	28.6 ± 3.8	28.3 ± 4.1	0.654
Waist circumference (cm)	94.8 ± 9.4	93.6 ± 10.2	0.475
Fasting plasma glucose (mg/dL)	108.4 ± 8.6	107.2 ± 9.1	0.418
HbA1c (%)	5.92 ± 0.28	5.89 ± 0.31	0.555
Fasting insulin (μ U/mL)	14.6 ± 5.2	14.2 ± 5.6	0.662
HOMA-IR	3.88 ± 1.42	3.76 ± 1.51	0.625

Characteristics	Intervention Group (n=75)	Control Group (n=75)	p-value
Total cholesterol (mg/dL)	198.4 ± 32.6	201.2 ± 34.8	0.612
LDL-cholesterol (mg/dL)	124.6 ± 28.4	126.8 ± 30.2	0.654
HDL-cholesterol (mg/dL)	46.2 ± 8.6	45.8 ± 9.2	0.784
Triglycerides (mg/dL)	152.8 ± 48.6	148.4 ± 46.2	0.576
hs-CRP (mg/L)	3.24 ± 1.68	3.12 ± 1.74	0.677
Baseline fiber intake (g/day)	16.8 ± 4.2	17.2 ± 4.6	0.591

Data presented as mean $\pm$ SD or n (%). HOMA-IR: homeostatic model assessment of insulin resistance; hs-CRP: high-sensitivity C-reactive protein

Dietary Compliance

Analysis of monthly food records demonstrated good dietary compliance. At 6 months, the intervention group achieved mean dietary fiber intake of 37.2 ± 5.8 g/day compared to 19.4 ± 4.2 g/day in the control group ($p < 0.001$). Whole grain servings averaged 3.4 ± 0.8 servings/day in the intervention group versus 1.2 ± 0.6 servings/day in the control group ($p < 0.001$).

Primary Outcomes: Changes in Glycemic Parameters

At 6 months, both groups demonstrated improvements in glycemic parameters, with significantly greater reductions observed in the intervention group (Table 2).

Table 2: Changes in Glycemic Parameters from Baseline to 6 Months

Parameters	Intervention Group (n=67)	Control Group (n=68)	p-value
Fasting Plasma Glucose (mg/dL)			
Baseline	108.4 ± 8.6	107.2 ± 9.1	0.418
3 months	99.2 ± 7.8	103.6 ± 8.4	0.003
6 months	93.6 ± 7.2	101.1 ± 8.6	<0.001
Mean change at 6 months	-14.8 ± 6.2	-6.1 ± 5.4	<0.001
HbA1c (%)			
Baseline	5.92 ± 0.28	5.89 ± 0.31	0.555
3 months	5.66 ± 0.26	5.78 ± 0.28	0.011
6 months	5.44 ± 0.24	5.71 ± 0.27	<0.001
Mean change at 6 months	-0.48 ± 0.22	-0.18 ± 0.19	<0.001

Parameters	Intervention Group (n=67)	Control Group (n=68)	p-value
Fasting Insulin (μU/mL)			
Baseline	14.6 ± 5.2	14.2 ± 5.6	0.662
6 months	11.2 ± 4.4	12.8 ± 5.2	0.051
Mean change at 6 months	-3.4 ± 2.6	-1.4 ± 2.8	<0.001
HOMA-IR			
Baseline	3.88 ± 1.42	3.76 ± 1.51	0.625
6 months	2.96 ± 1.18	3.42 ± 1.34	0.034
Mean change at 6 months	-0.92 ± 0.48	-0.34 ± 0.41	<0.001

Data presented as mean ± SD. HOMA-IR: homeostatic model assessment of insulin resistance

The mean reduction in fasting plasma glucose was 14.8 ± 6.2 mg/dL in the intervention group compared to 6.1 ± 5.4 mg/dL in the control group (p<0.001). HbA1c decreased by 0.48 ± 0.22% versus 0.18 ± 0.19% respectively (p<0.001). HOMA-IR reduction was significantly greater in the intervention group (0.92 ± 0.48 vs 0.34 ± 0.41, p<0.001), indicating improved insulin sensitivity.

Secondary Outcomes

Significant improvements in anthropometric measures and metabolic parameters were observed in the intervention group compared to controls (Table 3).

Table 3: Changes in Secondary Outcomes from Baseline to 6 Months

Outcomes	Intervention Group (n=67)	Control Group (n=68)	p-value
Anthropometric Measurements			
Weight loss (kg)	4.6 ± 2.1	1.8 ± 1.9	<0.001
BMI reduction (kg/m ²)	1.7 ± 0.8	0.7 ± 0.6	<0.001
Waist circumference reduction (cm)	5.8 ± 2.4	2.4 ± 2.1	<0.001
Lipid Profile Changes (mg/dL)			
Total cholesterol change	-18.6 ± 14.2	-8.4 ± 12.6	<0.001
LDL-cholesterol change	-14.2 ± 11.8	-6.8 ± 10.4	<0.001
HDL-cholesterol change	+4.6 ± 3.2	+1.8 ± 2.8	<0.001
Triglycerides change	-24.8 ± 16.4	-10.2 ± 14.8	<0.001

Outcomes	Intervention Group (n=67)	Control Group (n=68)	p-value
Inflammatory Marker			
hs-CRP change (mg/L)	-1.28 ± 0.84	-0.46 ± 0.72	<0.001
Diabetes Incidence			
New diabetes cases, n (%)	3 (4.0)	11 (14.7)	0.021
Normoglycemia Achievement			
Regression to normal glucose, n (%)	42 (62.7)	18 (26.5)	<0.001

Data presented as mean ± SD or n (%). BMI: body mass index; hs-CRP: high-sensitivity C-reactive protein

The intervention group achieved significantly greater weight loss (4.6 ± 2.1 kg vs 1.8 ± 1.9 kg, $p < 0.001$) and waist circumference reduction (5.8 ± 2.4 cm vs 2.4 ± 2.1 cm, $p < 0.001$). Lipid profile improvements were superior in the intervention group, with greater reductions in total cholesterol, LDL-cholesterol, and triglycerides, and larger increases in

HDL-cholesterol (all $p < 0.001$). The inflammatory marker hs-CRP decreased more substantially in the intervention group (-1.28 ± 0.84 mg/L vs -0.46 ± 0.72 mg/L, $p < 0.001$).

Notably, diabetes incidence during the 6-month study period was significantly lower in the intervention group compared to controls (4.0% vs 14.7%, $p = 0.021$). Conversely, regression to normoglycemia was achieved in 62.7% of intervention group participants versus 26.5% of controls ($p < 0.001$).

Subgroup Analysis

Subgroup analyses stratified by baseline BMI (< 28 vs ≥ 28 kg/m²) and age (< 50 vs ≥ 50 years) demonstrated consistent benefits of the intervention across all subgroups, with no significant interaction effects observed (data not shown).

Safety and Adverse Events

No serious adverse events were reported in both the study groups. Mild gastrointestinal symptoms (bloating, increased flatulence) during the first 2-3 weeks were reported by 18 participants (24%) in the intervention group, which resolved with gradual fiber increase adjustments and no adverse events reported in the control group. No participants discontinued the study due to intervention-related adverse events.

Discussion

This prospective interventional study demonstrates that a structured high-fiber, whole grain-enriched dietary intervention produces clinically meaningful improvements in glycemic control, insulin sensitivity, and metabolic parameters in individuals with prediabetes. The intervention group achieved superior reductions in fasting plasma glucose, HbA1c, and HOMA-IR compared to standard dietary recommendations, accompanied by favorable changes in body composition, lipid profile, and inflammatory markers. Most notably, the intervention resulted in a 73% relative risk reduction in diabetes incidence and substantially higher rates of regression to normoglycemia over the 6-month study period.

Our findings align with and extend previous evidence regarding the metabolic benefits of dietary fiber and whole grains. The mean fasting glucose reduction of 14.8 mg/dL observed in our intervention group is clinically significant and comparable to effects reported in the Diabetes Prevention Program, where intensive lifestyle intervention reduced diabetes incidence by 58% [4]. The 0.48% reduction in HbA1c achieved in our study is particularly noteworthy, as even modest improvements in HbA1c among prediabetic individuals have been associated with reduced long-term diabetes risk and cardiovascular complications [13].

The mechanisms underlying the favorable metabolic effects of high-fiber, whole grain-enriched diets are multifactorial. Dietary fiber, particularly soluble fiber abundant in whole grains, oats, and legumes, forms viscous solutions that delay gastric emptying and slow carbohydrate absorption, thereby attenuating postprandial glucose excursions [7]. The low glycemic index of whole grain products, attributed to their intact bran and germ layers, results in more gradual glucose release compared to refined grains [5]. Additionally, whole grains are rich in magnesium, which serves as a cofactor for numerous enzymes involved in glucose metabolism and has been inversely associated with diabetes risk in epidemiological studies [14].

Beyond direct glycemic effects, our study documented significant improvements in insulin sensitivity, as evidenced by HOMA-IR reduction of 0.92 in the intervention group. This finding is consistent with proposed mechanisms whereby dietary fiber modulates gut microbiota composition, promoting production of short-chain fatty acids that enhance insulin sensitivity through activation of G-protein coupled receptors and modulation of inflammatory pathways [9]. The substantial reduction in hs-CRP observed in our intervention group supports this anti-inflammatory mechanism and suggests broader metabolic benefits beyond glucose regulation.

The superior weight loss and waist circumference reduction achieved in the intervention group likely contributed to improved metabolic outcomes. High-fiber diets promote satiety through multiple mechanisms, including gastric distension, delayed gastric emptying, and enhanced secretion of satiety hormones such as GLP-1 and peptide YY [8]. The energy density reduction inherent in whole grain-rich dietary patterns facilitates spontaneous energy restriction while maintaining dietary satisfaction, thereby enhancing adherence to weight management efforts [15].

The lipid profile improvements observed in our study are consistent with established cholesterol-lowering effects of soluble fiber, which binds bile acids and increases hepatic cholesterol utilization for bile acid synthesis. The magnitude of LDL-cholesterol reduction (14.2 mg/dL) and triglyceride reduction (24.8 mg/dL) achieved in our intervention group provides additional cardiovascular benefits beyond glucose control, addressing the comprehensive metabolic risk profile characteristic of prediabetic individuals.

Perhaps most clinically significant, our intervention reduced diabetes incidence by 73% relative to controls over the 6-month study period. While this represents a relatively short follow-up duration, the substantial reduction in incident diabetes cases and the high proportion achieving normoglycemia regression suggest sustained metabolic improvement. These findings underscore the potential of food-based dietary interventions as practical, cost-effective strategies for diabetes prevention that can be implemented at the population level [12].

The practical implications of our findings are substantial. Unlike pharmaceutical interventions or isolated nutrient supplements, whole food-based dietary approaches emphasizing whole grains offer sustainable, culturally adaptable strategies that provide multiple nutritional benefits. The intervention protocol utilized in our study emphasized readily available, affordable food sources and did not require specialized products, enhancing feasibility for real-world implementation in diverse healthcare settings and populations. The safety profile of the intervention group receiving a structured high-fiber, whole grain-enriched dietary plan (≥ 35 g fiber/day) was considered to be safe.

Several limitations of our study warrant consideration. The relatively short 6-month duration limits assessment of long-term diabetes prevention and sustainability of dietary changes. The open-label design introduces potential for performance bias, though the use of objective biochemical outcomes partially mitigates this concern. The study was conducted in a single center with motivated participants receiving intensive dietary counselling, which may limit generalizability to routine clinical practice settings with less intensive support. Additionally, we did not include detailed microbiota analysis or assessment of specific fiber types, which would provide mechanistic insights into individual response variability.

Study strengths include the prospective randomized design, adequate sample size with good retention rates, comprehensive assessment of multiple metabolic parameters, implementation of a food-based rather than supplement-based intervention, and rigorous dietary compliance monitoring through

detailed food records. The pragmatic nature of the intervention enhances clinical applicability and translation into practice guidelines.

Conclusion

This prospective interventional study provides compelling evidence that a structured high-fiber, whole grain-enriched dietary intervention significantly improves glycemic control, insulin sensitivity, body composition, lipid profile, and inflammatory status in individuals with prediabetes. The intervention achieved clinically meaningful reductions in fasting glucose and HbA1c, with 73% relative risk reduction in diabetes incidence and substantial increases in regression to normoglycemia compared to standard dietary recommendations. These findings support the implementation of dietary patterns emphasizing ≥ 35 g fiber daily and ≥ 3 servings of whole grains as an effective, evidence-based strategy for diabetes prevention in high-risk populations.

The magnitude of metabolic improvements achieved through dietary modification alone underscores the critical role of nutritional therapy as first-line intervention for prediabetes management. The practical, food-based nature of this intervention, utilizing readily available whole grain products and high-fiber foods, enhances feasibility for widespread implementation in clinical practice and public health programs. Healthcare providers should emphasize increased whole grain consumption and dietary fiber intake as foundational components of diabetes prevention counselling for at-risk individuals.

Future research should focus on long-term follow-up studies to evaluate sustained diabetes prevention, cardiovascular outcomes, and durability of dietary behavior change. Investigation of specific fiber types, gut microbiome responses, and genetic factors influencing individual response variability would provide valuable mechanistic insights. Additionally, implementation studies examining cost-effectiveness and scalability of structured dietary interventions in diverse healthcare systems and resource settings would facilitate translation of these findings into effective population-level diabetes prevention strategies.

Acknowledgment: I express my sincere gratitude for the invaluable support and cooperation provided by the staff, participants, and my co-authors/colleagues who contributed to this study.

Conflicts of interest: There are no conflicts of interest.

References

1. Cho NH, Shaw JE, Karuranga S, Huang Y, da Rocha Fernandes JD, Ohlrogge AW, et al. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract.* 2018;138:271-281. PMID: 29496507.
2. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care.* 2018;41(5):917-928. PMID: 29567642
3. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. Prediabetes: a high-risk state for diabetes development. *Lancet.* 2012;379(9833):2279-2290. PMID: 22683128
4. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med.* 2002;346(6):393-403. PMID: 11832527
5. Weickert MO, Pfeiffer AFH. Impact of dietary fiber consumption on insulin resistance and the prevention of type 2 diabetes. *J Nutr.* 2018;148(1):7-12. PMID: 29378044.
6. Aune D, Norat T, Romundstad P, Vatten LJ. Whole grain and refined grain consumption and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies. *Eur J Epidemiol.* 2013;28(11):845-858. PMID: 24158434
7. Noronha JC, Braunstein CR, Blanco Mejia S, Khan TA, Kendall CWC, Wolever TMS, Leiter LA, et al. The Effect of Small Doses of Fructose and Its Epimers on Glycemic Control: A

- Systematic Review and Meta-Analysis of Controlled Feeding Trials. *Nutrients*. 2018;10(11):1805. PMID: 30463314
8. Byrne CS, Chambers ES, Morrison DJ, Frost G. The role of short chain fatty acids in appetite regulation and energy homeostasis. *Int J Obes (Lond)*. 2015;39(9):1331-1338. PMID: 26303350
 9. Koh A, De Vadder F, Kovatcheva-Datchary P, Bäckhed F. From dietary fiber to host physiology: short-chain fatty acids as key bacterial metabolites. *Cell*. 2016;165(6):1332-1345. PMID: 27259147
 10. Li X, Cai X, Ma X, Jing L, Gu J, Bao L, et al. Short- and Long-Term Effects of Wholegrain Oat Intake on Weight Management and Glucolipid Metabolism in Overweight Type-2 Diabetics: A Randomized Control Trial. *Nutrients*. 2016;8(9):549. PMID: 27618090.
 11. An R. Diabetes diagnosis and nutrition facts label use among US adults, 2005-2010. *Public Health Nutr*. 2016;19(12):2149-56. PMID: 26483168.
 12. Hu EA, Pan A, Malik V, Sun Q. White rice consumption and risk of type 2 diabetes: meta-analysis and systematic review. *BMJ*. 2012;344:e1454. PMID: 22422870
 13. Zhang X, Gregg EW, Williamson DF, Barker LE, Thomas W, Bullard KM, et al. A1C level and future risk of diabetes: a systematic review. *Diabetes Care*. 2010;33(7):1665-1673. PMID: 20587727
 14. Larsson SC, Wolk A. Magnesium intake and risk of type 2 diabetes: a meta-analysis. *J Intern Med*. 2007;262(2):208-214. PMID: 17645588
 15. Kristensen M, Jensen MG, Riboldi G, Petronio M, Bügel S, Toubro S, et al. Wholegrain vs. refined wheat bread and pasta. Effect on postprandial glycemia, appetite, and subsequent ad libitum energy intake in young healthy adults. *Appetite*. 2010;54(1):163-169. PMID: 19808071