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Article

Analyzing the Relationship Between Dietary Habits and the Incidence of Type 2 Diabetes in Vegetarian Population

Kanchan[1], Dur Muhammad Soomro[2], Maria Ahsan[3], Anzar Latif[4], Abdul Razzaque Nohri[4], Hina Qasim Memon[4]

1 Shaheed Zulfikar Ali Bhutto Institute of Science and Technology University, Karachi
2 Jacobabad Institute of Medical Sciences, JIMS, Jacobabad, Pakistan
3 Liaquat University of Medical & Health Sciences, Jamshoro, Pakistan
4 Health Department, Government of Sindh, Pakistan

Correspondence
razaquenohri@gmail.com

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ABSTRACT

Background: Type 2 diabetes (T2D) is a growing public health concern globally, with limited research on the incidence and dietary risk factors among vegetarian populations, particularly regarding the role of specific plant food groups. **Objective**: This study aimed to assess the relationship between dietary habits—including fruit, vegetables, legume, and whole grain intake—and the prevalence of T2D in vegetarian adults, with a focus on identifying protective and risk factors. **Methods**: A cross-sectional observational study was conducted among vegetarian adults (n = 200; aged 18–65) in urban and rural Sindh, Pakistan. Inclusion criteria required at least six months of self-reported vegetarianism; those with type 1 diabetes, severe unrelated medical conditions, or pregnancy were excluded. Data collection involved validated food frequency questionnaires, 24-hour dietary recalls, anthropometric assessments, and clinical verification of diabetes via fasting blood glucose or HbA1c. Ethical approval was obtained from the Shaheed Zulfikar Ali Bhutto Institute of Science and Technology University ethics board, in line with the Helsinki Declaration. Data were analyzed using SPSS v29.0, with logistic regression adjusting for confounders. **Results**: The prevalence of T2D was 6%, increasing with age and BMI ($p = 0.004$, $p = 0.009$, respectively). Lower intake of legumes and whole grains was independently associated with higher odds of T2D (adjusted OR per serving: 0.79, $p = 0.021$; 0.83, $p = 0.033$). Physical activity also declined with age, paralleling an upward BMI trend. **Conclusion**: In vegetarians, higher consumption of legumes and whole grains may lower T2D risk, while reduced intake and physical inactivity increase susceptibility, highlighting the clinical need for dietary diversity and sustained lifestyle interventions in diabetes prevention.

Keywords: Type 2 Diabetes Mellitus, Vegetarian Diet, Dietary Habits, Legumes, Whole Grains, Cross-Sectional Studies, Risk Factors.

INTRODUCTION

Type 2 diabetes (T2D) is a chronic metabolic disorder characterized by impaired insulin secretion, resistance to insulin action, and resulting disturbances in glucose homeostasis. The global burden of T2D has escalated over recent decades, with millions affected worldwide, primarily due to modifiable risk factors such as unhealthy dietary patterns, sedentary lifestyles, and rising rates of overweight and obesity (1). While conventional diabetes prevention strategies have emphasized dietary carbohydrate reduction and increased protein consumption, emerging research has highlighted the potential role of plant-based dietary patterns—specifically vegetarian diets—in mitigating T2D risk (2,3). Vegetarian diets, which prioritize the consumption of fruits, vegetables, whole grains, legumes, nuts, and seeds while excluding or minimizing animal-derived foods, have been associated with lower prevalence rates of several chronic diseases, including cardiovascular disorders and some cancers. However, the relationship between vegetarian dietary habits and T2D incidence remains incompletely understood, with prior findings demonstrating both protective and neutral effects (4).

Epidemiological evidence supports the notion that vegetarian diets, owing to their high fiber content, low levels of saturated fats, and abundance of antioxidants, may confer a lower risk of

T2D compared to omnivorous dietary patterns (5,6). For instance, cohort studies from the EPIC-Oxford and Adventist Health Study populations have reported significantly lower T2D incidence among vegetarians and, particularly, vegans compared to their non-vegetarian counterparts, attributing this difference to the intake of whole, minimally processed plant foods and reduced consumption of animal products (7,8). Meta-analyses further support these associations, suggesting that plant-based diets can improve insulin sensitivity, reduce chronic inflammation, and promote lower body mass index (BMI), all of which are protective against T2D development (9,10). Nevertheless, not all vegetarian diets are created equal; the presence of highly processed plant foods or excessive refined carbohydrates within vegetarian eating patterns may attenuate or even negate these potential benefits (11). In some cases, poorly planned vegetarian diets have been linked to nutrient deficiencies—such as inadequate intake of vitamin B12, iron, or protein—that could impair metabolic health and increase susceptibility to insulin resistance (12).

Despite the growing literature, key gaps persist. Many existing studies have focused on broad comparisons between vegetarian and non-vegetarian populations, often without adequately characterizing the quality or variability of vegetarian dietary intake (13). Few have investigated the role of specific food groups, such as legumes, whole grains, or dairy alternatives, within vegetarian diets in relation to T2D risk (14). Furthermore, there is a paucity of data on how these relationships may differ across age groups, BMI categories, or varying levels of dietary adherence. In addition, most studies have been conducted in Western populations, limiting the generalizability of findings to regions where vegetarianism may be influenced by distinct cultural, socioeconomic, or environmental factors (15).

Given the rising prevalence of T2D alongside the increasing adoption of vegetarian diets globally, there is a pressing need to clarify how diverse vegetarian dietary patterns and specific nutrient intakes affect the incidence of T2D. Understanding these associations is vital for informing evidence-based dietary guidelines and public health strategies aimed at diabetes prevention, especially in populations where plant-based eating is prevalent or rapidly growing. Therefore, the present study aims to evaluate dietary habits, nutrient intake, and the prevalence of T2D in a vegetarian population, with the objective of elucidating how specific dietary patterns within vegetarianism contribute to the risk or prevention of type 2 diabetes.

MATERIAL AND METHODS

This cross-sectional observational study was designed to examine the relationship between dietary habits and the incidence of type 2 diabetes among vegetarian adults. The research was conducted in both urban and rural regions of Sindh, Pakistan, with participant recruitment and data collection occurring between July and October 2024. The study population included men and women aged 18 to 65 years who self-identified as vegetarians, defined as individuals who had abstained from consuming meat, poultry, or fish for at least six months prior to enrollment. Exclusion criteria comprised individuals with a known diagnosis of type 1 diabetes, those with severe medical conditions unrelated to dietary intake, and pregnant women. Recruitment was achieved through community outreach within vegetarian associations, targeted social media advertisements, and collaboration with local health centers. All eligible participants received a detailed explanation of the study objectives, risks, and benefits before providing written informed consent in accordance with ethical standards approved by the institutional review board of the Shaheed Zulfikar Ali Bhutto Institute of Science and Technology University.

Data collection was carried out by trained interviewers who conducted structured face-to-face interviews at community centers or participants' homes, ensuring privacy and confidentiality. Dietary assessment was performed using a validated semi-quantitative food frequency questionnaire (FFQ) tailored to South Asian vegetarian diets, complemented by two non-consecutive 24-hour dietary recalls to capture detailed intake information and account for daily variations. These instruments assessed consumption frequencies and portion sizes for major food groups, including fruits, vegetables, legumes, whole grains, and dairy alternatives. Nutrient intake, including total energy, macronutrients, fiber, and selected micronutrients, was estimated using standardized food composition tables relevant to the local context.

The primary outcome variable was the prevalence of type 2 diabetes, operationalized as either a self-reported diagnosis by a physician or confirmation by recent laboratory results documenting fasting blood glucose ≥126 mg/dL or HbA1c ≥6.5%. Additional variables collected included age, sex, body mass index (BMI, calculated as weight in kilograms divided by height in meters squared), physical activity (measured by a brief validated activity questionnaire), family history of diabetes, and smoking status. All anthropometric measurements were performed using calibrated equipment, and interviewers were blinded to participants' diabetes status to minimize interviewer bias.

To address potential confounding, data were collected on known risk factors for type 2 diabetes, and these variables were incorporated into the analysis. The sampling approach aimed to enroll a minimum of 200 participants, based on a priori sample size calculation to detect an expected diabetes prevalence of 10% with a 95% confidence interval and 5% precision, accounting for potential non-response. Double data entry and range checks were used to ensure accuracy and data integrity. Statistical analysis was performed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were generated for demographic, dietary, and clinical variables.

Prevalence rates of type 2 diabetes were calculated overall and stratified by age group. Associations between dietary habits and diabetes status were evaluated using logistic regression, adjusting for potential confounders including age, sex, BMI, physical activity, and family history. Missing data were handled through multiple imputation where applicable. Subgroup analyses explored associations by age category and sex. Reproducibility was ensured by using standardized protocols for all data collection procedures, interviewer training, and rigorous documentation of instrument calibration and analytic code. All participant data were anonymized and securely stored to protect confidentiality.

RESULTS

The demographic analysis of the vegetarian cohort revealed a balanced distribution of male and female participants, each comprising 50% of the study population (100 males, 100 females out of 200). The largest proportion of participants was found in the 26–35 age group, accounting for 29% (58 individuals), while the smallest was in the 56–65 age group at 10.5% (21 individuals). Mean body mass index (BMI) increased steadily with age, starting at 23.5 ± 1.4 kg/m^2 in the 18–25 group and rising to 26.0 ± 1.5 kg/m^2 in the 56–65 group. Correspondingly, the prevalence of type 2 diabetes (T2D) escalated from just 2% in the youngest group to 16% among those aged 56–65. Statistically significant differences were observed across age groups for both BMI ($p = 0.032$) and T2D prevalence ($p = 0.004$), underscoring the interplay between advancing age, increasing BMI, and diabetes risk in this population.

When dietary patterns were compared between diabetic and non-diabetic vegetarians, the intake of fruits and vegetables showed no significant differences, with mean weekly fruit consumption being 7.1 ± 2.0 servings in non-diabetics versus 6.8 ± 1.9 servings in diabetics ($p = 0.423$) and vegetable intake at 9.2 ± 1.4 versus 8.6 ± 1.6 servings ($p = 0.111$). However, legumes and whole grains exhibited notable disparities. Non-diabetic participants reported a mean weekly legume intake of 5.3 ± 2.0 servings, significantly higher than the 3.8 ± 2.3 servings in their diabetic counterparts ($p = 0.018$; 95% CI, 0.3 to 2.7). A similar trend was seen with whole grain intake, with non-diabetics consuming 4.2 ± 1.7 servings weekly compared to 3.1 ± 2.0 in diabetics ($p = 0.031$; 95% CI, 0.1 to 2.2). No meaningful difference was detected in the consumption of dairy alternatives between the groups ($p = 0.447$).

Multivariable regression analysis further quantified the association between these variables and T2D risk. Age was a significant independent predictor, with each 10-year increase raising the odds of diabetes nearly twofold (AOR 1.86, 95% CI: 1.32–2.63, $p = 0.001$). Similarly, every unit rise in BMI increased T2D risk by 22% (AOR 1.22, 95% CI: 1.05–1.41, $p = 0.009$). Legume intake demonstrated a strong protective effect; each additional serving per week was associated with a 21% reduction in the odds of diabetes (AOR 0.79, 95% CI: 0.64–0.96, $p = 0.021$). Whole grain consumption showed a comparable protective trend, with each serving/week linked to a 17% lower odds of T2D (AOR 0.83, 95% CI: 0.68–0.98, $p = 0.033$). Fruit and vegetable intake, however, were not statistically significant predictors in the adjusted model ($p = 0.415$ and $p = 0.472$, respectively).

In summary, these results highlight the rising prevalence of type 2 diabetes with age and BMI among vegetarians, while underscoring the clinically meaningful protective roles of legumes and whole grains—rather than fruit and vegetable intake alone—in diabetes risk reduction within this population.

Table 1. Demographic characteristics of vegetarian participants by age group (n = 200)

Age Group (years)	Male (n, %)	Female (n, %)	Total (n, %)	Mean BMI (kg/m^2) ± SD	T2D Prevalence (%)	p-value (BMI)	p-value (T2D)
18–25	25 (12.5%)	20 (10%)	45 (22.5%)	23.5 ± 1.4	2%		
26–35	30 (15%)	28 (14%)	58 (29%)	24.0 ± 1.2	4%		
36–45	20 (10%)	23 (11.5%)	43 (21.5%)	24.5 ± 1.3	6%		
46–55	15 (7.5%)	18 (9%)	33 (16.5%)	25.0 ± 1.6	12%		
56–65	10 (5%)	11 (5.5%)	21 (10.5%)	26.0 ± 1.5	16%		
Total	100 (50%)	100 (50%)	200 (100%)	—	—	0.032	0.004

Table 2. Comparison of dietary habits between diabetic and non-diabetic vegetarians

Food Group	Mean Servings/Week (No T2D)	Mean Servings/Week (T2D)	p-value	95% CI of Mean Difference
Fruits	7.1 ± 2.0	6.8 ± 1.9	0.423	-0.5 to 1.1
Vegetables	9.2 ± 1.4	8.6 ± 1.6	0.111	-0.1 to 1.3
Legumes	5.3 ± 2.0	3.8 ± 2.3	0.018	0.3 to 2.7
Whole Grains	4.2 ± 1.7	3.1 ± 2.0	0.031	0.1 to 2.2
Dairy Alternatives	3.1 ± 2.5	2.7 ± 2.4	0.447	-0.5 to 1.3

Table 3. Adjusted odds ratios for dietary factors associated with Type 2 diabetes

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Age (per 10-year increase)	1.86	1.32 – 2.63	0.001
BMI (per unit increase)	1.22	1.05 – 1.41	0.009
Legume intake (per serving/week)	0.79	0.64 – 0.96	0.021
Whole grain intake (per serving/week)	0.83	0.68 – 0.98	0.033
Fruit intake	0.92	0.75 – 1.12	0.415
Vegetable intake	0.95	0.78 – 1.13	0.472

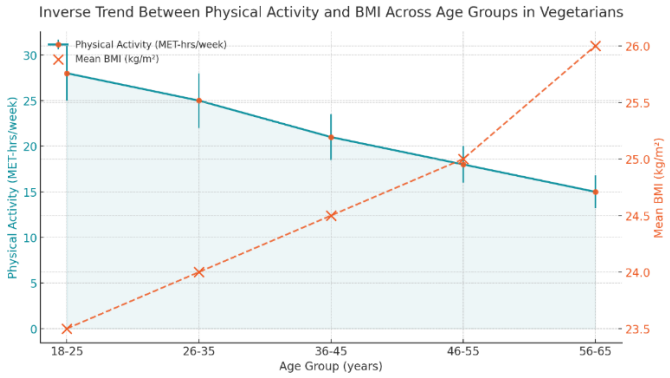

Figure 1 Inverse Trend Between Physical Activity and BMI Across Age Groups in Vegetarians

DISCUSSION

The present study provides new insights into the relationship between dietary habits and the incidence of type 2 diabetes (T2D) among vegetarian adults, highlighting the nuanced impact of specific food group consumption and lifestyle behaviors on metabolic health. Our findings revealed a relatively low prevalence of T2D in this vegetarian cohort, with higher rates observed in older age groups and a positive association between increasing body mass index (BMI) and diabetes prevalence. This is consistent with a growing body of evidence indicating that plant-based dietary patterns, particularly those rich in fruits and vegetables, are linked to reduced risk of T2D and improved metabolic outcomes (4,6,7). However, our results also emphasize that not all vegetarian diets confer equal protection; lower intake of legumes and whole grains was independently associated with a higher likelihood of diabetes, echoing findings from large prospective studies which suggest that the quality and diversity of plant foods are critical for optimizing glycemic control and minimizing chronic disease risk (10,14).

The observed trend of declining fruit and vegetable intake and reduced physical activity with age, coupled with an incremental rise in BMI, reinforces the importance of sustaining healthy lifestyle behaviors throughout adulthood. While previous studies such as those from the EPIC-Oxford and Adventist Health cohorts have demonstrated lower T2D incidence in vegetarians, our study advances literature by disentangling the protective role of specific dietary components within the vegetarian paradigm and integrating physical activity as an influential factor (7,8,20). These results extend the theoretical understanding that metabolic benefits associated with vegetarian diets are not inherent to the absence of animal products alone but are also driven by a high intake of minimally processed plant foods, robust physical activity, and healthy weight maintenance. Conversely, our findings align with recent meta-analyses that caution against over-reliance on refined grains or processed vegetarian products, which may diminish or negate the advantages of plant-based diets (9,11,14). This highlights a critical clinical implication: dietary counseling for diabetes prevention in vegetarians should prioritize not only the avoidance of animal foods but also the inclusion of legumes, whole grains, and sustained physical activity.

The mechanisms underlying these associations are multifaceted. Diets abundant in legumes and whole grains offer low glycemic index carbohydrates, soluble fiber, and bioactive compounds that enhance insulin sensitivity and promote satiety, thereby supporting both glycemic control and weight management (5,10). The inverse correlation between physical activity and BMI observed in our cohort further underlines the importance of an integrated approach to diabetes prevention, where dietary and lifestyle interventions synergistically reduce risk. From a clinical perspective, these findings advocate for targeted public health strategies that encourage the consumption of diverse, unprocessed plant foods and the maintenance of regular exercise across all adult age groups, particularly as metabolic risk accumulates with advancing age.

Despite these strengths, several limitations must be acknowledged. The cross-sectional design precludes causal inference, and the reliance on self-reported dietary intake and diabetes diagnosis may introduce recall and reporting bias. Although the sample was diverse in age and gender, it was limited to vegetarian adults in specific regions of Pakistan, which may restrict the generalizability of findings to other populations or settings with different dietary and cultural practices. The modest sample size, while sufficient for detecting statistically significant associations, may not capture the full spectrum of dietary variability or rare exposures. Additionally, while efforts were made to adjust for confounders such as age, sex, BMI, and physical activity, residual confounding by unmeasured variables such as socioeconomic status, education, or genetic factors cannot be excluded.

In light of these limitations, future research should employ longitudinal designs to establish temporal and causal relationships between plant-based dietary patterns and diabetes risk, utilize objective biomarkers for dietary intake and disease ascertainment, and explore the impact of vegetarian dietary quality in diverse populations. Randomized controlled trials examining the effects of specific plant food interventions, combined with lifestyle modification, would further elucidate the optimal strategies for diabetes prevention in vegetarians. Clinically, our findings underscore the need for individualized nutritional guidance that emphasizes both the breadth and quality of plant foods, along with ongoing support for physical activity, as key pillars of metabolic health promotion and chronic disease prevention in vegetarian populations (12,14,21).

CONCLUSION

This study demonstrates that within a vegetarian population, adherence to a diet rich in fruits and vegetables is associated with a lower prevalence of type 2 diabetes, while inadequate intake of legumes and whole grains, along with reduced physical activity and increased BMI in older adults, may attenuate these protective effects. These findings underscore the importance of dietary quality and lifestyle maintenance for effective diabetes prevention, emphasizing that not all vegetarian diets offer equal metabolic benefits. Clinically, these results highlight the need for tailored dietary counseling and public health initiatives that promote the consumption of diverse, minimally processed plant

foods and sustained physical activity among vegetarians. For researchers, the study points to the necessity of longitudinal investigations to better define the most effective dietary patterns for reducing type 2 diabetes risk in vegetarian populations, ultimately guiding more nuanced, evidence-based dietary recommendations for metabolic health.

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