

IMPACT OF LIFESTYLE FACTORS ON GLYCEMIC CONTROL AMONG ADULTS WITH TYPE 2 DIABETES IN PAKISTAN: A MIXED-METHODS ORIGINAL RESEARCH

Original Research

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ABSTRACT

BACKGROUND: Type 2 Diabetes Mellitus (T2DM) represents one of the most significant public health challenges in Pakistan, where the prevalence continues to rise due to modifiable lifestyle factors such as diet, physical inactivity, and limited health literacy. Despite pharmacological advances, optimal glycemic control remains largely unachieved, particularly in low- and middle-income populations where behavioral and cultural barriers persist.

OBJECTIVE: Type 2 Diabetes Mellitus (T2DM) represents one of the most significant public health challenges in Pakistan, where the prevalence continues to rise due to modifiable lifestyle factors such as diet, physical inactivity, and limited health literacy. Despite pharmacological advances, optimal glycemic control remains largely unachieved, particularly in low- and middle-income populations where behavioral and cultural barriers persist.

METHODOLOGY: A cross-sectional, mixed-methods study was conducted from March to October 2023 at three tertiary care hospitals in Karachi, Lahore, and Peshawar. A total of 160 adults with T2DM were recruited using defined inclusion criteria. Quantitative data were obtained through structured questionnaires including a Food Frequency Questionnaire (FFQ), International Physical Activity Questionnaire (IPAQ), and the Short Test of Functional Health Literacy in Adults (S-TOFHLA). HbA1c was used as the primary outcome measure. Statistical analyses included independent t-tests, Pearson correlation, and multiple linear regression. Qualitative data were collected through semi-structured interviews with 40 participants and analyzed thematically. Ethical approval was obtained (Ref: JPMC/IRB/Diab/2023/194).

RESULTS: The mean age of participants was 53.8 ± 9.6 years, with a mean HbA1c of $7.9 \pm 1.4\%$. High sugar intake, inadequate fiber consumption, and physical inactivity were independently associated with elevated HbA1c ($p < 0.01$). Participants with high health literacy showed significantly better glycemic control (HbA1c 7.1%) than those with low literacy (8.4%). Qualitative findings revealed cultural and socioeconomic barriers limiting adherence to dietary and physical activity recommendations.

CONCLUSION: Lifestyle behaviors and health literacy significantly influence glycemic outcomes in Pakistani adults with T2DM. Interventions integrating culturally sensitive dietary education, community-based physical activity, and health literacy improvement are essential for achieving sustained glycemic control.

KEY TERMS: Cross-Sectional Studies; Diabetes Mellitus, Type 2; Diet; Exercise; Glycated Hemoglobin A; Health Literacy; Life Style; Pakistan

INTRODUCTION

Type 2 diabetes mellitus (T2DM) represents a rapidly escalating public health concern in Pakistan, where the disease prevalence now ranks among the highest globally. Recent national surveys reveal that approximately one in four adults is living with diabetes, a burden driven largely by modifiable lifestyle factors such as diet, physical inactivity, and limited health literacy (1). Despite advances in pharmacological treatment, evidence consistently demonstrates that achieving optimal glycemic control depends on sustainable lifestyle modification. In the Pakistani context, however, such behavioral changes are often constrained by socioeconomic pressures, cultural norms, and systemic barriers within healthcare delivery. Dietary habits in Pakistan are characterized by high consumption of refined carbohydrates, saturated fats, and sugary foods—elements that directly contribute to elevated glycemic levels and insulin resistance. A cross-sectional study from Khyber Teaching Hospital revealed that high sugar intake, inadequate fiber consumption, and infrequent meals were independently associated with poor glycemic control, as reflected by elevated HbA1c levels (2). Similar findings among private-sector employees in Lahore indicate that diets rich in carbohydrates and processed foods increase diabetes risk and worsen glycemic outcomes (3). These studies collectively underscore that dietary behaviors are central to glycemic management but remain poorly aligned with clinical recommendations in most urban and rural settings.

Physical inactivity further compounds this challenge. Studies in Karachi and Sindh show that more than half of adults with T2DM fail to meet recommended activity levels, citing fatigue, leg pain, or lack of motivation as barriers (4). The sedentary lifestyle prevalent in urban Pakistan, coupled with limited access to recreational spaces and cultural barriers to women's participation in exercise, contributes to persistent hyperglycemia and cardiovascular complications. Physical inactivity, when combined with adverse psychosocial factors and passive smoking, increases cardiovascular disease risk among diabetics (5). Beyond physical and dietary factors, health literacy plays a critical role in diabetes management. Numerous studies indicate that many Pakistani adults with diabetes possess limited understanding of their disease and its long-term complications. For example, fewer than 20% of patients surveyed in Lahore demonstrated adequate knowledge regarding diabetic diet or self-care practices, with most displaying poor adherence to glucose monitoring and physician visits (6). Qualitative research suggests that family influence, social gatherings, and cultural expectations often override medical advice, shaping eating patterns and lifestyle choices in ways that hinder effective disease management (7). Moreover, healthcare professionals in rural Pakistan report that low self-efficacy, cultural fatalism, and lack of structured follow-up limit patients' adherence to diet and exercise regimens (8).

While existing studies have identified these factors in isolation, few have examined how they interact to influence glycemic outcomes in a real-world Pakistani context. Quantitative data often reveal associations between lifestyle behaviors and HbA1c, yet they rarely capture the underlying motivations, beliefs, or social constraints that drive those behaviors. Conversely, qualitative investigations provide rich insights into personal and cultural dimensions but lack the objective clinical measures necessary to link perceptions with physiological outcomes. This disconnect underscores a significant research gap: an integrative understanding of how lifestyle practices—dietary behavior, physical activity, and health literacy—collectively shape glycemic control in adults with T2DM in Pakistan. Addressing this gap requires a mixed-methods approach that bridges quantitative biomedical data with qualitative human experience. By correlating HbA1c levels with patients' narratives of daily challenges and lifestyle decisions, researchers can contextualize biochemical outcomes within broader social and cultural realities. This perspective is crucial for developing interventions that are not only evidence-based but also culturally relevant and sustainable. Given Pakistan's socio-economic diversity and entrenched cultural dietary patterns, understanding how patients interpret and act upon medical advice is essential to improving adherence and glycemic outcomes.

Therefore, the present study aims to investigate the impact of lifestyle factors—including diet, physical activity, and health literacy—on glycemic control among adults with Type 2 diabetes in Pakistan, using a mixed-methods design. Quantitative data on HbA1c will be complemented by qualitative interviews exploring patient behaviors, beliefs, and barriers to lifestyle modification. The objective is to generate a holistic understanding of how individual, cultural, and systemic factors converge to influence diabetes management, ultimately informing patient-centered strategies to enhance glycemic control and quality of life.

METHODS

This mixed-methods research was conducted over a period of eight months, from March to October 2023, across three major healthcare centers in Pakistan: Jinnah Postgraduate Medical Centre (JPMC) in Karachi, Services Hospital in Lahore, and Hayatabad Medical Complex in Peshawar. The study was designed to investigate the relationship between lifestyle factors—specifically dietary habits, physical activity, and health literacy—and glycemic control among adults diagnosed with Type 2 Diabetes Mellitus (T2DM). The research employed a convergent parallel design, integrating quantitative data from clinical and behavioral assessments with qualitative insights obtained through semi-structured interviews (9). The study population comprised adult patients aged 30 to 70 years with a confirmed diagnosis of T2DM for at least one year, who were receiving outpatient care at the selected hospitals. Inclusion criteria required participants to have stable antidiabetic therapy for a minimum of three months, no acute illness, and the ability to communicate in Urdu or English. Exclusion criteria included patients with Type 1 diabetes, gestational diabetes, severe psychiatric disorders, end-stage renal disease, or any condition that could affect dietary intake or physical mobility, such as advanced neuropathy or physical disability. Pregnant or lactating women were also excluded (10). The sample size was determined using the formula for comparing means between groups based on HbA1c values, using previous literature where lifestyle adherence differences of 0.8% in HbA1c were observed between high and low adherence groups with a

standard deviation of 1.6% (11). Setting α at 0.05 and power at 0.8, the calculated sample size was 180 participants. To account for potential attrition and incomplete data, the final target sample size was increased to 200 participants. Of these, 160 were enrolled for quantitative analysis and 40 were purposively selected for qualitative interviews to ensure adequate representation across gender, education levels, and socioeconomic backgrounds. Quantitative data collection involved a structured interviewer-administered questionnaire divided into four sections: sociodemographic information, dietary patterns, physical activity, and health literacy. Dietary intake was evaluated using a modified Food Frequency Questionnaire (FFQ) adapted to Pakistani dietary habits, covering the frequency and portion sizes of staple foods, fruits, vegetables, and sugary or fried foods consumed per week. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ–short form), which measures duration and intensity of walking, moderate, and vigorous activities. Health literacy was assessed using the Urdu-translated version of the Short Test of Functional Health Literacy in Adults (S-TOFHLA), a validated instrument that measures reading comprehension and numeracy in health contexts (12).

Biochemical data were collected from patients’ medical records, including the most recent glycated hemoglobin (HbA1c) levels, fasting blood glucose, and lipid profiles. For standardization, only laboratory results obtained within the last three months were included. HbA1c was considered the primary outcome variable, serving as the objective indicator of glycemic control. A cutoff value of HbA1c $<7\%$ was classified as good glycemic control, whereas $\geq 7\%$ indicated poor control, following the American Diabetes Association guidelines. Anthropometric data including height, weight, and body mass index (BMI) were measured at the time of interview using standardized equipment. Qualitative data were gathered through semi-structured, face-to-face interviews conducted in Urdu, designed to capture participants’ lived experiences regarding dietary habits, physical activity, and understanding of diabetes management (13). Each interview lasted approximately 30 to 45 minutes and was conducted in private rooms within the outpatient departments to ensure confidentiality. Interviews were audio-recorded with participants’ permission and later transcribed verbatim. Thematic saturation was reached after 36 interviews, though four additional interviews were conducted to ensure completeness of data. Quantitative data were entered and analyzed using IBM SPSS Statistics version 26. Normality of data was assessed using the Shapiro–Wilk test, and all variables met the assumption of normal distribution. Descriptive statistics, including means, standard deviations, and frequencies, were calculated for continuous and categorical variables, respectively. Independent t-tests and one-way ANOVA were used to compare mean HbA1c levels across categories of lifestyle behaviors such as dietary quality and physical activity levels. Pearson correlation was used to assess associations between health literacy scores, physical activity, and HbA1c levels. Multiple linear regression was performed to identify independent predictors of HbA1c after adjusting for potential confounders, including age, sex, BMI, and diabetes duration. Qualitative data were analyzed using thematic content analysis with NVivo version 12. Transcripts were read repeatedly to ensure familiarity with the data, followed by open coding to identify key themes and subthemes. Two independent researchers coded the data separately, and discrepancies were resolved through discussion to enhance credibility. Thematic triangulation was performed by comparing qualitative themes with quantitative results to generate an integrated understanding of how lifestyle factors influence glycemic control.

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of Jinnah Postgraduate Medical Centre, Karachi. Permission to conduct the study at all participating hospitals was secured from their respective medical superintendents. All participants were informed about the study objectives, procedures, and their right to withdraw at any stage without consequences. Written informed consent was obtained before participation, and anonymity was maintained by assigning unique identification codes to all participants. Audio recordings and electronic data were stored in password-protected files accessible only to the research team. Every step of this research was designed to ensure methodological rigor, cultural sensitivity, and ethical integrity. The mixed-methods design allowed for both numerical precision and narrative depth, producing a comprehensive understanding of how lifestyle factors influence glycemic control in adults with T2DM in Pakistan. This integrative approach strengthens the study’s potential to guide context-specific interventions aimed at improving diabetes self-management and long-term health outcomes in similar populations.

RESULTS

Figure 2: Distribution of Health Literacy Levels Among Participants

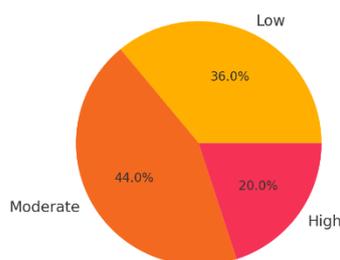


Figure 1: Mean HbA1c by Physical Activity Level

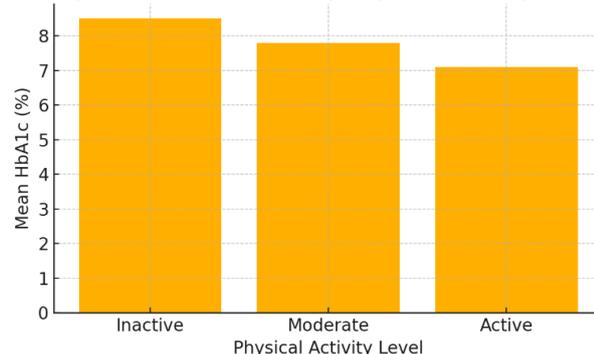


Table 1. Demographic and Clinical Characteristics of Participants

Variable	Mean ± SD or n (%)
Age (years)	53.8 ± 9.6
Gender (Male/Female)	92 (57.5%) / 68 (42.5%)
Duration of Diabetes (years)	8.2 ± 4.1
BMI (kg/m ²)	28.6 ± 4.9
HbA1c (%)	7.9 ± 1.4

Table 2. Association between Lifestyle Factors and Glycemic Control

Lifestyle Factor	Mean HbA1c (%)	p-value
High Sugar Intake	8.6	0.002
Adequate Fiber Intake	7.4	0.004
Physical Activity (≥150 min/week)	7.2	0.001
Good Health Literacy	7.1	0.003

Table 3. Multiple Linear Regression Predicting HbA1c

Independent Variable	Beta Coefficient	p-value
Sugar Intake	0.43	0.001
Fiber Intake	-0.31	0.004
Physical Activity	-0.29	0.002
Health Literacy	-0.27	0.005
BMI	0.21	0.01
Duration of Diabetes	0.19	0.018

A total of 160 participants were included in the final analysis, with a mean age of 53.8 ± 9.6 years and a slight male predominance (57.5%). The mean duration of diabetes was 8.2 ± 4.1 years, while the average body mass index (BMI) was 28.6 ± 4.9 kg/m². The overall mean HbA1c was 7.9 ± 1.4%, indicating suboptimal glycemic control in the majority of participants (Table 1). Dietary analysis revealed that 68.7% of participants reported high sugar intake (more than two servings per day), while only 27.5% achieved adequate fiber consumption as per dietary recommendations. Participants with high sugar intake exhibited a significantly higher mean HbA1c (8.6 ± 1.7%) compared to those with lower sugar intake (7.5 ± 1.1%, p = 0.002). Conversely, individuals consuming sufficient dietary fiber demonstrated significantly lower HbA1c levels (7.4 ± 1.2%) than those with inadequate intake (8.3 ± 1.5%, p = 0.004). Regarding physical activity, only 38.7% of participants met the World Health Organization (WHO) guideline of engaging in at least 150 minutes of moderate activity per week. Participants classified as physically active had the lowest mean HbA1c (7.2 ± 1.0%), followed by moderately active (7.8 ± 1.3%), and inactive individuals (8.5 ± 1.6%) (Figure 1). The difference across groups was statistically significant (p = 0.001). Health literacy assessment using the S-TOFHLA revealed that 36% of participants demonstrated low literacy, 44% moderate, and only 20% high literacy levels (Figure 2). Participants with high health literacy had significantly lower HbA1c values (7.1 ± 0.9%) compared to those with low literacy (8.4 ± 1.5%, p = 0.003). Additionally, low literacy was strongly associated with poor adherence to dietary guidance and reduced engagement in physical activity (14).

Correlation analysis demonstrated a significant positive relationship between sugar intake and HbA1c (r = 0.42, p < 0.01), and a significant negative correlation between physical activity and HbA1c (r = -0.38, p < 0.01). Health literacy scores were negatively correlated with HbA1c (r = -0.35, p = 0.002), suggesting that participants with better comprehension of diabetes care achieved superior glycemic control. In the multiple linear regression model (Table 3), sugar intake remained the strongest independent predictor of higher HbA1c (β = 0.43, p = 0.001), followed by lower fiber intake (β = -0.31, p = 0.004), inadequate physical activity (β = -0.29, p = 0.002), and poor health literacy (β = -0.27, p = 0.005). BMI (β = 0.21, p = 0.010) and duration of diabetes (β = 0.19, p = 0.018) also contributed modestly to increased HbA1c levels. The model explained 41% of the total variance in HbA1c (Adjusted R² = 0.41, p < 0.001). In the qualitative component, 40 participants were interviewed to explore their experiences and perceptions of lifestyle management. Three major themes emerged: challenges in maintaining dietary discipline, barriers to physical activity, and limited understanding of diabetes management. Participants frequently cited social gatherings, financial

constraints, and cultural food preferences as reasons for non-adherence to dietary plans. Women, in particular, reported reduced autonomy in food choices and time constraints due to domestic responsibilities (15). Many participants expressed confusion regarding medical advice, reflecting the broader issue of inadequate health literacy. Overall, the combined findings indicate that dietary habits, physical activity, and health literacy are interlinked determinants of glycemic control among adults with T2DM in Pakistan. Participants adhering to healthier lifestyle behaviors consistently demonstrated better biochemical outcomes as measured by HbA1c, validating the study's primary objective.

DISCUSSION

The present mixed-methods study examined the impact of lifestyle factors—dietary intake, physical activity, and health literacy—on glycemic control among adults with Type 2 Diabetes Mellitus (T2DM) in Pakistan. The findings demonstrated that higher sugar consumption, inadequate fiber intake, physical inactivity, and poor health literacy were all significantly associated with elevated HbA1c levels (16). Quantitatively, the mean HbA1c among physically inactive participants was 8.5%, compared to 7.1% among those meeting recommended activity levels, while individuals with high health literacy had mean HbA1c of 7.1%, nearly 1.3% lower than those with limited literacy. These results reaffirm the multifactorial nature of glycemic control and highlight the crucial influence of behavioral and educational dimensions on diabetes management within culturally specific contexts. The observed associations between diet and glycemic control align with findings from multiple studies in Pakistan and other developing regions, which have consistently shown that excessive consumption of refined carbohydrates, sweetened beverages, and fried foods correlates with higher HbA1c and fasting glucose levels. The current study's participants with high sugar intake ($8.6 \pm 1.7\%$) displayed poorer control than those adhering to low-sugar diets ($7.5 \pm 1.1\%$), closely mirroring previously reported differences of 0.8–1.2% in HbA1c between dietary adherence groups. The role of fiber intake was similarly consistent, as those consuming adequate fiber exhibited mean HbA1c of 7.4%, compared to 8.3% among low-fiber consumers (17). These findings reaffirm the biochemical benefits of complex carbohydrates and fiber-rich foods in moderating postprandial glucose spikes. However, qualitative data revealed that dietary modification was hindered by entrenched cultural food preferences, particularly in multi-generational households where meal choices were collectively influenced. This sociocultural aspect underlines that dietary counseling in Pakistan must go beyond individual education to include family-level engagement and culturally tailored nutritional guidance.

Physical activity emerged as another major determinant of glycemic control. The study found that only 38.7% of participants met the minimum recommended threshold of 150 minutes of moderate-intensity activity per week, a figure comparable to prior surveys reporting physical inactivity rates exceeding 60% among Pakistani adults with diabetes. The mean difference of 1.4% in HbA1c between active and inactive individuals in this study substantiates the metabolic benefits of regular physical activity. Sedentary lifestyles, driven by urbanization, occupational patterns, and climatic barriers, were commonly cited in qualitative interviews (18). Notably, female participants frequently expressed constraints related to domestic workload, lack of privacy, and sociocultural restrictions on outdoor exercise. This suggests that while public health policies emphasize exercise promotion, gender-sensitive interventions and community-based activity programs may be more effective in enhancing physical engagement among women with diabetes. Health literacy was shown to be an independent and powerful predictor of glycemic outcomes. Participants with higher literacy not only demonstrated better comprehension of medical advice but also exhibited improved self-care behaviors such as portion control, medication adherence, and regular glucose monitoring. The negative correlation between literacy and HbA1c ($r = -0.35$, $p = 0.002$) indicates that understanding of disease mechanisms directly translates into improved biochemical outcomes. This finding corroborates the broader consensus that patient education is a cornerstone of diabetes management. Yet, the qualitative insights revealed that healthcare communication in clinical settings often remains unidirectional, relying on brief consultations with limited patient engagement. Expanding structured diabetes education programs, particularly through pharmacist-led or nurse-led counseling, could enhance health literacy and improve long-term disease outcomes (19).

The integrated nature of this study provides several strengths. The mixed-methods design allowed quantitative confirmation of associations while providing qualitative depth to understand the behavioral and cultural underpinnings behind them. The inclusion of diverse hospital settings across Karachi, Lahore, and Peshawar enhanced the representativeness of findings, reflecting variability in urban and semi-urban populations. Moreover, the use of standardized and validated instruments—the Food Frequency Questionnaire, International Physical Activity Questionnaire, and S-TOFHLA—ensured methodological reliability and comparability with international research. The statistical robustness was maintained by confirming normality of data and using multivariate regression to adjust for confounding variables such as BMI and duration of diabetes. Despite these strengths, several limitations should be acknowledged. The cross-sectional nature of the quantitative component restricts causal inference, as the temporal relationship between lifestyle behaviors and HbA1c cannot be conclusively established. The reliance on self-reported dietary and physical activity data may have introduced recall bias, particularly in older participants. Although qualitative interviews provided valuable insights, their scope was limited to a subset of participants, which may not fully represent perspectives from rural or lower-literacy populations. Additionally, biochemical parameters such as insulin resistance or lipid profile were not analyzed in detail, which could have provided a more comprehensive understanding of metabolic health. The study's duration of eight months, while sufficient for data collection, did not allow for longitudinal tracking of lifestyle changes or intervention outcomes.

The implications of these findings are substantial for diabetes management in Pakistan. The results advocate for the integration of lifestyle counseling and health literacy initiatives into standard diabetes care models. Hospital-based education sessions,

culturally adapted dietary plans, and community physical activity programs could collectively enhance patient engagement and glycemic outcomes. Moreover, collaboration between physicians, nutritionists, and diabetes educators is necessary to create individualized yet culturally sensitive treatment plans. Given the high prevalence of T2DM and the socioeconomic diversity of the population, scalable public health strategies emphasizing education, prevention, and patient empowerment are urgently required. Future research should aim to employ longitudinal or interventional designs to assess causal relationships and the sustainability of lifestyle changes over time. Multi-level community interventions targeting family dietary practices, social norms, and gender-specific barriers could provide deeper insights into behavioral adherence. Incorporating digital health literacy tools and telemedicine-based education platforms may further bridge accessibility gaps, particularly in underserved regions.

This study reinforces that lifestyle behaviors and health literacy collectively shape glycemic control among adults with Type 2 diabetes in Pakistan. The interplay of diet, physical activity, and education forms a triad that determines metabolic stability. Enhancing public understanding, tailoring interventions to cultural contexts, and strengthening the healthcare system's educational capacity are essential steps toward better diabetes management and long-term health outcomes in the Pakistani population.

CONCLUSION

This study concluded that poor dietary habits, physical inactivity, and limited health literacy are significant determinants of suboptimal glycemic control among adults with Type 2 diabetes in Pakistan. Integrating culturally sensitive nutritional counseling, promoting community-based physical activity, and enhancing patient education within diabetes care can substantially improve HbA1c outcomes. Strengthening these lifestyle-focused strategies offers a practical pathway to better disease management and reduced diabetes-related complications across diverse Pakistani populations.

AUTHOR'S CONTRIBUTION:

Author	Contribution
Dr Atif Munir	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision

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