PREVALENCE OF UNDIAGNOSED PREDIABETES IN YOUNG ADULTS IN PAKISTAN AND ITS ASSOCIATION WITH SEDENTARY BEHAVIOR: A SCREENING-BASED ORIGINAL STUDY

Original Research

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ABSTRACT

BACKGROUND: Prediabetes is a growing metabolic concern in Pakistan, particularly among young adults, where lifestyle transitions and sedentary behavior contribute to early glucose dysregulation. Despite its reversibility, prediabetes often remains undiagnosed, leading to delayed intervention and a heightened risk of developing type 2 diabetes mellitus.

OBJECTIVE: To determine the prevalence of undiagnosed prediabetes among young adults in Pakistan and to assess its association with sedentary behavior across urban populations.

METHODOLOGY: A cross-sectional, community-based study was conducted between January and August 2023 in three urban centers—Lahore, Karachi, and Peshawar. A total of 186 apparently healthy adults aged 18–35 years were enrolled using stratified random sampling. Data were collected through structured questionnaires, anthropometric measurements, and biochemical screening, including fasting plasma glucose (FPG) and glycated hemoglobin (HbA1c) testing. Sedentary behavior and physical activity levels were evaluated using the International Physical Activity Questionnaire–Short Form (IPAQ-SF). Statistical analyses were performed using SPSS version 26, applying chi-square tests, t-tests, and binary logistic regression.

RESULTS: The overall prevalence of undiagnosed prediabetes was 14.2%. Participants with sedentary time ≥7 hours per day had significantly higher odds of prediabetes (Adjusted Odds Ratio: 2.71; 95% CI: 1.28–5.74; p=0.009). Overweight and obesity (BMI ≥25 kg/m²) were also strongly associated (AOR: 2.36; 95% CI: 1.05–5.28; p=0.037). The mean HbA1c among prediabetic participants was 6.1 ± 0.2%, compared to 5.3 ± 0.4% in normoglycemic individuals.

CONCLUSION: A notable prevalence of undiagnosed prediabetes exists among young adults in Pakistan, with sedentary behavior identified as a significant modifiable risk factor. Targeted public health interventions emphasizing early screening and active lifestyles are essential to curb the rising diabetes burden.

KEY TERMS: Adolescents, Body Mass Index, Diabetes Mellitus Type 2, Pakistan, Physical Inactivity, Prediabetic State, Sedentary Behavior

INTRODUCTION

Prediabetes represents a crucial yet often overlooked stage in the continuum of glucose intolerance, marking the period where blood glucose levels are elevated beyond normal but have not yet reached the diagnostic threshold for diabetes mellitus. It is a reversible state, but without timely intervention, it frequently progresses to type 2 diabetes mellitus (T2DM), a chronic metabolic disorder with profound public health implications. In Pakistan, a country undergoing rapid urbanization and lifestyle transitions, the growing burden of prediabetes—particularly among young adults—poses an alarming challenge to the healthcare system and the economy. Young adults, often considered a relatively healthy group, are increasingly exhibiting metabolic abnormalities traditionally associated with older populations. This rising trend is intricately linked with sedentary behavior, unhealthy dietary patterns, and urban living conditions that promote physical inactivity. Recent national-level surveys have revealed a steep escalation in the prevalence of diabetes and prediabetes across Pakistan. The *Diabetes Prevalence Survey of Pakistan (DPS-PAK)* estimated that approximately 10.9% of adults have prediabetes, while 16.9% already have diabetes, underscoring the widespread metabolic vulnerability in the general population (1). Similarly, a systematic review and meta-analysis found that the pooled prevalence of prediabetes in Pakistan was approximately 11.4%, highlighting a consistent upward trajectory over the past two decades (2). What makes this trend particularly concerning is its extension into younger age groups, where lifestyle risk factors—especially physical inactivity—play a pivotal role. The *NDSP-10 study* revealed that younger adults under 45 years already exhibit significant dysglycemia and multiple cardiometabolic risk factors, including obesity and central adiposity, suggesting that metabolic risk now begins early in life (3).

Physical inactivity, or sedentary behavior, is increasingly recognized as an independent risk factor for glucose dysregulation. In Pakistan, urbanization has fostered environments conducive to sedentary lifestyles, characterized by long hours of sitting, screen use, and low engagement in physical activity. Studies among young adults, such as medical students in Mirpurkhas, identified a 12% prevalence of prediabetes, with the majority of affected individuals leading sedentary lives and consuming unhealthy diets (4). At a broader population level, physical inactivity remains a dominant risk factor associated with early-onset diabetes in young Pakistanis, alongside familial predisposition, obesity, and poor dietary habits (5). The high prevalence of sedentary behavior among urban youth underscores a behavioral shift toward energy imbalance, exacerbated by technological dependence and reduced opportunities for outdoor physical engagement. The physiological mechanism linking sedentary lifestyles with prediabetes is multifaceted. Prolonged sitting reduces glucose uptake by skeletal muscles, impairs insulin sensitivity, and increases adiposity, thereby triggering systemic inflammation and metabolic dysregulation. International studies have corroborated these findings, demonstrating that replacing sedentary time with even light physical activity can substantially reduce mortality and metabolic risk in individuals with prediabetes (6). In the Pakistani context, where sedentary behavior is compounded by cultural and infrastructural barriers to exercise—particularly among women and youth—understanding its association with prediabetes is crucial for designing effective preventive strategies.

The social implications of undiagnosed prediabetes in young adults are profound. This age group constitutes the most economically productive segment of society; therefore, early metabolic impairment translates into long-term health and economic costs. Without early detection and lifestyle modification, these individuals face a high probability of developing T2DM before midlife, along with its complications such as cardiovascular disease, neuropathy, and renal impairment. Moreover, given the asymptomatic nature of prediabetes, most affected individuals remain undiagnosed until complications emerge. Studies in Pakistan have consistently emphasized the need for community-based screening programs that target young adults and incorporate lifestyle education (7). Despite growing evidence, there remains a significant gap in understanding the prevalence of undiagnosed prediabetes specifically among young adults in Pakistan, and how it correlates with sedentary behavior. Most national surveys aggregate data across all adult age groups, masking the early onset of glucose dysregulation in the younger population. Furthermore, limited screening initiatives exist for non-hospitalized young individuals, particularly in educational institutions and community settings, where preventive measures could be most impactful. Addressing this gap is vital for public health policymakers aiming to design age-appropriate, culturally tailored interventions that promote physical activity and early screening.

Therefore, the present research aims to determine the prevalence of undiagnosed prediabetes among young adults in Pakistan and to explore its association with sedentary behavior. By identifying the magnitude of this hidden metabolic burden and its behavioral correlates, the study seeks to inform targeted screening and preventive strategies that can be implemented at the community and institutional level to curb the progression of prediabetes into full-blown diabetes. Objective of the study is to determine the prevalence of undiagnosed prediabetes among young adults in Pakistan and evaluate its association with sedentary behavior, thereby providing evidence to guide future public health screening and lifestyle intervention programs.

METHODS

The present cross-sectional screening-based study was conducted to determine the prevalence of undiagnosed prediabetes among young adults in Pakistan and to examine its association with sedentary behavior. The study was carried out in three major cities representing different provinces of the country—Lahore (Punjab), Karachi (Sindh), and Peshawar (Khyber Pakhtunkhwa)—to ensure geographical diversity and representation of urban youth populations. Data collection was conducted over a period of eight months, from January 2023 to August 2023, across selected universities, community centers, and outpatient screening clinics. The study was approved by the

Ethical Review Committee of the National University of Medical Sciences, Islamabad, and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. The target population comprised young adults aged 18 to 35 years, who were apparently healthy and had no prior diagnosis of diabetes mellitus. Participants were recruited using a stratified random sampling approach to ensure proportional representation from each city and gender. The sample size was estimated using Cochran's formula, based on the prevalence of prediabetes reported in prior studies in Pakistan (approximately 11.4%) with a 95% confidence level and a 5% margin of error. The calculated minimum sample size was 155, which was increased by 20% to account for potential non-responses or incomplete data, resulting in a total sample of 186 participants (8,9). Recruitment was carried out through campus announcements, health awareness campaigns, and voluntary participation during community-based screening camps organized in collaboration with local health authorities.

Eligibility criteria included young adults aged between 18 and 35 years, residents of the study cities for at least six months, and those willing to undergo biochemical screening for glucose tolerance. Individuals with a known diagnosis of diabetes mellitus, those currently on glucocorticoid therapy, individuals with chronic illnesses such as cardiovascular disease, thyroid disorders, or polycystic ovary syndrome, and pregnant or lactating women were excluded to minimize confounding influences on glucose metabolism. Data collection was conducted in two phases: questionnaire-based assessment and biochemical screening. In the first phase, a structured, pretested questionnaire was administered by trained healthcare professionals to gather data on sociodemographic characteristics, medical history, dietary habits, and sedentary behavior. Sedentary time was quantified using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), which records time spent sitting, watching television, or using digital devices during a typical day. Physical activity levels were categorized according to World Health Organization (WHO) guidelines as inactive (<150 minutes/week of moderate activity), moderately active (150–300 minutes/week), or active (>300 minutes/week). Participants' anthropometric measurements—including height, weight, waist circumference, and body mass index (BMI)—were recorded following standardized procedures. Weight was measured to the nearest 0.1 kg using a calibrated digital scale, and height was measured to the nearest 0.1 cm using a stadiometer. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²) and classified according to WHO criteria (10).

In the second phase, participants underwent biochemical screening to detect undiagnosed prediabetes. Fasting blood samples were collected after an overnight fast of at least eight hours. Fasting plasma glucose (FPG) and glycated hemoglobin (HbA1c) levels were measured at certified laboratories using automated analyzers (Cobas c501, Roche Diagnostics) (11). Prediabetes was defined as an FPG between 100–125 mg/dL or HbA1c between 5.7–6.4%, following the American Diabetes Association (ADA) diagnostic criteria. Participants meeting either criterion were classified as having prediabetes, while those with higher values were referred for confirmatory diagnostic evaluation. To ensure quality control, all instruments were calibrated daily, and duplicate readings were taken for 10% of randomly selected participants. Laboratory analyses were conducted under strict biosafety protocols, and all data were anonymized using participant identification codes.

The primary outcome of interest was the prevalence of undiagnosed prediabetes, while the secondary outcome was the association between sedentary behavior and prediabetes status. Continuous variables such as age, BMI, and sedentary time were expressed as mean ± standard deviation (SD), whereas categorical variables like gender, activity level, and family history of diabetes were presented as frequencies and percentages. Prior to inferential analysis, normality of data distribution was confirmed using the Shapiro–Wilk test. Between-group comparisons were conducted using independent sample t-tests for continuous variables and chi-square tests for categorical variables. The association between sedentary behavior and prediabetes was examined through binary logistic regression analysis, adjusting for potential confounders including BMI, dietary habits, and family history of diabetes. Results were reported as adjusted odds ratios (AOR) with 95% confidence intervals (CI). A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). To address ethical considerations, participants diagnosed with prediabetes during screening were counseled about lifestyle modification and referred to primary healthcare centers for follow-up. Educational brochures on physical activity and dietary management were distributed at the conclusion of each screening session. Confidentiality of personal information was maintained throughout the study process, and participation was entirely voluntary. This methodologically rigorous study employed a cross-sectional design integrating biochemical testing with behavioral assessment to estimate the prevalence of undiagnosed prediabetes in young adults and evaluate its association with sedentary behavior across urban regions of Pakistan. The use of validated tools, standardized laboratory procedures, and robust statistical analyses ensured reliability and reproducibility of findings, thus providing a solid foundation for evidence-based recommendations in public health screening and preventive strategies.

RESULTS
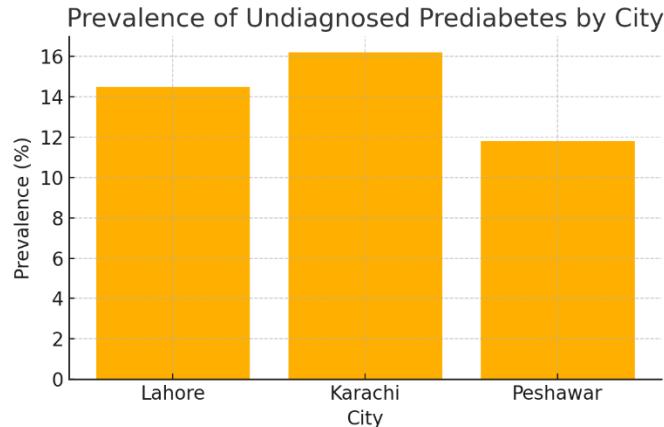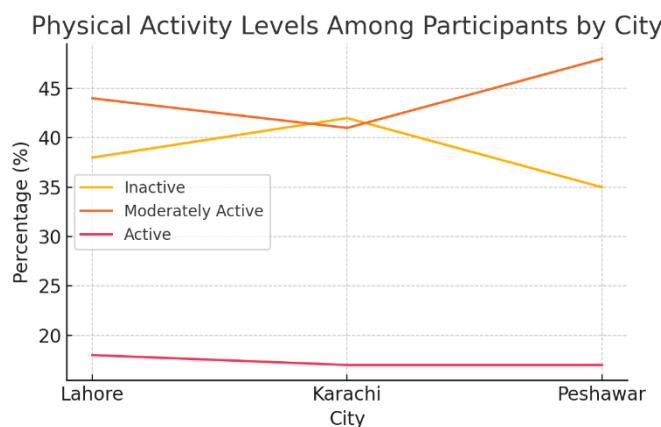
A total of 186 young adults aged between 18 and 35 years participated in the study, with a mean age of 25.8 ± 4.2 years. The response rate across the three cities—Lahore, Karachi, and Peshawar—was 93.5%. The sample consisted of 98 (52.7%) males and 88 (47.3%) females. The overall mean body mass index (BMI) was 26.1 ± 3.9 kg/m², with 29.0% of participants classified as overweight and 18.3% as obese according to WHO criteria. Family history of diabetes was reported by 39.2% of participants. The overall prevalence of undiagnosed prediabetes was 14.2% (n=26), while 2.1% (n=4) were found to have glucose values within the diabetic range and were referred for further evaluation. Among the cities, the prevalence of prediabetes was highest in Karachi (16.2%), followed by Lahore (14.5%) and Peshawar (11.8%). The mean fasting plasma glucose among all participants was 95.3 ± 11.6 mg/dL, while the mean HbA1c level was 5.5 ± 0.6% (Rondanelli et al., 2023) (12). Participants diagnosed with prediabetes had significantly higher mean HbA1c levels (6.1 ± 0.2%) compared to normoglycemic individuals (5.3 ± 0.4%) (p < 0.001).

In terms of sedentary behavior, the mean daily sitting time was 6.8 ± 2.3 hours, with 38.7% classified as physically inactive (<150 minutes of moderate activity per week), 44.1% as moderately active, and 17.2% as active according to WHO guidelines. There was a notable city-wise difference, with Karachi participants showing the highest inactivity rate (42%), followed by Lahore (38%) and Peshawar (35%), as illustrated in Figure 2.

Table 1. Demographic and clinical characteristics of study participants (n=186)

Variable	Mean ± SD / n (%)
Age (years)	25.8 ± 4.2
Gender (Male/Female)	98 (52.7%) / 88 (47.3%)
BMI (kg/m²)	26.1 ± 3.9
Overweight (BMI 25–29.9)	54 (29.0%)
Obese (BMI ≥30)	34 (18.3%)
Family history of diabetes	73 (39.2%)
Mean fasting glucose (mg/dL)	95.3 ± 11.6
Mean HbA1c (%)	5.5 ± 0.6
Prediabetes prevalence	26 (14.2%)

Participants with prediabetes demonstrated significantly higher BMI (28.3 ± 3.7 vs. 25.7 ± 3.8, p = 0.002) and longer average daily sedentary time (8.1 ± 2.0 vs. 6.5 ± 2.1 hours, p < 0.001) compared to normoglycemic individuals. Additionally, a higher proportion of prediabetic individuals were found to have a positive family history of diabetes (61.5% vs. 35.4%, p = 0.01).

Table 2. Association between physical activity level and prediabetes status

Physical Activity Category	Prediabetic (n=26)	Non-prediabetic (n=156)	Total (n=182)*
Inactive	16 (61.5%)	56 (35.9%)	72 (39.6%)

| Moderately Active | 8 (30.8%) | 74 (47.4%) | 82 (45.1%) |
| Active | 2 (7.7%) | 26 (16.7%) | 28 (15.3%) |

*Four participants excluded due to incomplete physical activity data.

Binary logistic regression analysis identified sedentary behavior (≥7 hours sitting per day) as an independent predictor of prediabetes (AOR = 2.71, 95% CI: 1.28–5.74, p = 0.009) after adjusting for BMI, gender, and family history. Overweight/obese participants were also at higher risk (AOR = 2.36, 95% CI: 1.05–5.28, p = 0.037). No significant gender difference was found (p = 0.41).

Table 3. Logistic regression model for predictors of undiagnosed prediabetes

Predictor Variable	Adjusted Odds Ratio (AOR)	95% CI	p-value
Sedentary time ≥7 hours/day	2.71	1.28–5.74	0.009
Overweight/Obese (BMI ≥25)	2.36	1.05–5.28	0.037
Family history of diabetes	2.08	0.96–4.49	0.062
Age (per 1-year increase)	1.07	0.98–1.17	0.113

Overall, the study demonstrated a moderate prevalence of undiagnosed prediabetes among young adults, with a strong statistical association between higher sedentary behaviors and elevated fasting glucose and HbA1c levels. These findings are visually summarized in Figure 1, which illustrates the variation in prediabetes prevalence by city, and Figure 2, depicting the distribution of physical activity levels among participants.

DISCUSSION

The present study identified a considerable prevalence of undiagnosed prediabetes among young adults in urban Pakistan, highlighting a growing public health concern that is often underestimated in this age group. The overall prevalence of 14.2% among apparently healthy individuals aged 18–35 years signifies a silent metabolic shift occurring early in life (13). This finding aligns with national data from the Diabetes Prevalence Survey of Pakistan (DPS-PAK), which estimated a prediabetes prevalence of 10.9% in adults aged 20 years and above. The slightly higher prevalence observed in the current study may be attributed to urban lifestyle patterns, dietary transitions, and the increasing sedentary behavior among youth in metropolitan areas such as Karachi and Lahore. The strong association between prolonged sedentary time and prediabetes observed in this study substantiates the hypothesis that physical inactivity is an independent determinant of glucose dysregulation. Participants with sedentary time exceeding seven hours per day exhibited 2.7 times higher odds of prediabetes after adjusting for confounders (14). This finding is consistent with global and regional evidence demonstrating that sedentary behavior contributes to impaired insulin sensitivity and increased fasting glucose levels even in individuals with normal body weight. Moreover, the mean daily sitting time of 6.8 hours observed among participants underscores a behavioral pattern that has become increasingly prevalent with the widespread use of digital devices and academic sedentary routines.

A comparison with prior studies conducted in Pakistan reinforces these observations. Screening-based investigations among university students in Mirpurkhas reported a 12% prevalence of prediabetes, strongly linked with obesity, lack of exercise, and family history of diabetes. Similarly, regional assessments in Narowal and Swat identified prediabetes prevalence rates of 30% and 21.4%, respectively, though these studies included broader age groups (15,16). The present study, focusing exclusively on young adults, demonstrates that the early onset of prediabetes is not confined to middle-aged or high-risk populations but extends into early adulthood, emphasizing the importance of community-based screening initiatives targeting this demographic (17). The role of obesity as a contributing factor was also evident. Participants with BMI ≥25 kg/m² were 2.3 times more likely to exhibit prediabetes compared to those with normal BMI. This relationship has been consistently reported in national and international literature, where overweight and central obesity have been shown to increase insulin resistance and hepatic glucose output. Interestingly, 47.3% of the current study's participants fell into the overweight or obese category, suggesting an early manifestation of metabolic risk. Urban dietary habits characterized by excessive intake of refined carbohydrates and reduced physical activity may have accelerated this trend (18).

The clustering of multiple risk factors—such as family history of diabetes, sedentary lifestyle, and obesity—appears to compound the metabolic vulnerability among young adults. The current findings support prior evidence that familial predisposition remains a strong, though non-modifiable, predictor of dysglycemia. In this study, 61.5% of prediabetic participants reported a positive family history of diabetes, a figure comparable to the 64% reported in prior medical college cohorts (19). This genetic and environmental interplay suggests that behavioral modification remains the most feasible and impactful preventive measure for this group. The implications of these findings extend beyond clinical screening to broader public health planning. Early identification of prediabetes in young populations presents a valuable opportunity to prevent the progression to type 2 diabetes, which carries substantial economic and health burdens. Interventions promoting structured physical activity, reduction of sedentary time, and dietary awareness can yield significant population-level benefits. The logistic regression results highlight that even modest behavioral modifications, such as reducing sitting

time, could substantially reduce prediabetes risk. These insights align with international evidence suggesting that replacing 30 minutes of sedentary behavior with light-intensity physical activity can lower cardiometabolic risk by up to 9% (20).

Despite its strengths, including multi-city sampling, use of objective biochemical markers, and validated physical activity assessment tools, the study had several limitations. The cross-sectional design precludes causal inference, limiting the ability to determine whether sedentary behavior directly caused prediabetes or merely coexisted as a related lifestyle factor. Furthermore, self-reported measures of physical activity through the IPAQ-SF are susceptible to recall bias, although standardized interviewer administration mitigated this risk. The study population consisted primarily of educated young adults from urban areas, potentially underrepresenting rural or lower socioeconomic groups where lifestyle patterns may differ. Additionally, despite biochemical verification through fasting plasma glucose and HbA1c, postprandial glucose testing was not conducted, which might have identified additional cases of impaired glucose tolerance. Nevertheless, the study provides a valuable addition to existing literature by focusing on an underexplored population—young, apparently healthy adults—and employing a multi-dimensional analysis of sedentary behavior as a metabolic risk factor. The robust statistical methodology and high response rate lend credibility to the observed associations. The integration of anthropometric, behavioral, and biochemical data enhances the study's comprehensiveness and replicability.

Future research should adopt longitudinal designs to establish temporal relationships between sedentary lifestyle and progression from prediabetes to diabetes. Additionally, incorporating objective accelerometer-based measurements could enhance accuracy in quantifying physical inactivity. Expanding research to rural populations would provide comparative insights into the urban-rural divide in prediabetes risk factors. Large-scale interventional studies assessing the impact of community-based physical activity programs and digital health awareness campaigns could further validate the efficacy of preventive strategies. The findings underscore an alarming yet modifiable trend of undiagnosed prediabetes among young adults in Pakistan, strongly associated with sedentary behavior and obesity. Early lifestyle interventions, targeted awareness programs, and routine screening of young adults are essential to curb the rising tide of metabolic disorders. The study reinforces that the path to diabetes prevention must begin much earlier than previously assumed, focusing on behavioral modification in youth to secure healthier futures for the nation's next generation.

CONCLUSION

The study concluded that a substantial proportion of young adults in Pakistan have undiagnosed prediabetes, with sedentary behavior emerging as a significant and independent risk factor. The findings emphasize the urgent need for early lifestyle interventions, regular community-based screening, and educational initiatives promoting physical activity. Addressing these modifiable behaviors during early adulthood can play a decisive role in preventing the future burden of type 2 diabetes and its associated complications in the country.

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INSIGHTS-JOURNAL OF
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Volume 1 Issue 1 (2025): Undiagnosed Prediabetes and Sedentary Behavior
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AUTHORS CONTRIBUTION

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