



Determinants of diabetes mellitus among adults aged ≥ 40 years: A case-control study in Banda Aceh

Faktor-faktor penentu diabetes mellitus pada dewasa usia ≥ 40 tahun: Studi kasus-kontrol di Banda Aceh

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Abstract

Diabetes mellitus is characterized by hyperglycemia and remains a growing global public health concern, including in Aceh Province, Indonesia. Several determinants have been associated with its occurrence, including age, obesity, physical inactivity, smoking, and family history. This study aimed to investigate the association between obesity, physical activity, smoking habits, family history, and diabetes mellitus. A case-control study was conducted among 46 participants, consisting of 23 patients with diabetes mellitus and 23 non-diabetic controls who underwent laboratory examinations at the Clinical Pathology Laboratory of Dr. Zainoel Abidin Regional General Hospital in Banda Aceh. Primary data were collected through interviews and structured questionnaires, and secondary data were obtained from medical records between January and August 2023. Data were analyzed using univariate analysis, chi-square tests, and multivariate logistic regression. The prevalence of diabetes mellitus was 5.9% in women and 5.2% in men. Obesity was significantly associated with diabetes mellitus ($p < 0.001$), with an odds ratio of 23.02. In contrast, physical activity, smoking status, and family history of diabetes showed no significant association with diabetes mellitus ($p > 0.05$). In conclusion, obesity is a major risk factor for diabetes mellitus. Regular monitoring and control of the body mass index are essential strategies for maintaining an ideal body weight and reducing the risk of diabetes mellitus.

Keywords: Diabetes mellitus, obesity, case control study, risk factors, Indonesia

Abstrak

Diabetes mellitus ditandai dengan hiperglikemia. Kasusnya terus meningkat secara global termasuk di Aceh, banyak faktor determinan diantaranya usia, obesitas, aktifitas fisik, akibat merokok dan riwayat keluarga. Tujuan penelitian ini untuk menyelidiki korelasi antara faktor risiko obesitas, aktivitas fisik, merokok dan riwayat penyakit dengan kejadian DM. Metode penelitian adalah desain case control sebanyak 46 orang, yang terdiri dari 23 kasus diabetes dan 23 bukan diabetes yang memeriksakan diri di laboratorium Patologi RSUD dr. Zainoel Abidin Banda Aceh. Pengumpulan data primer dilakukan dengan wawancara, kuesioner dan data sekunder dari Januari - Agustus 2023, kemudian data dianalisis secara univariat, bivariat dengan uji Chi-square, dan regresi logistik multivariat. Hasil, prevalensi diabetes mellitus ditemukan sekitar 5.9% wanita dan 5.2% laki-laki. Obesitas memiliki hubungan signifikan dengan kejadian diabetes mellitus ($p < 0.001$), dengan risiko sebesar 23.02. Aktivitas fisik, merokok dan riwayat diabetes tidak memiliki hubungan yang signifikan ($p > 0.05$). Kesimpulan, obesitas merupakan faktor penting terhadap terjadinya diabetes melitus. Pentingnya mengontrol dan pemantauan indeks massa tubuh secara rutin, untuk mengoptimalkan berat badan ideal.

Kata Kunci: Diabetes mellitus, obesitas, case control, risiko, Indonesia

Introduction

The growing burden of noncommunicable diseases (NCDs) has become a major public health challenge in Indonesia. This phenomenon is reflected in the country's epidemiological transition, often referred to as the "Triple Burden of Disease," characterized by the coexistence of communicable diseases, emerging infectious diseases, and an increasing prevalence of NCDs, including diabetes mellitus (Risesdas, 2018). NCDs account for a substantial proportion of healthcare expenditures under Indonesia's National Health Insurance (JKN) system and increasingly affect not only older adults but also younger populations (Kemenkes RI, 2019, 2020). Consequently, the rising prevalence of diabetes mellitus has prompted global commitments to strengthen prevention and control strategies, particularly in low- and middle-income countries (LMICs). Addressing diabetes mellitus is therefore essential for achieving the Sustainable Development Goals (SDGs), particularly the target of reducing premature mortality from NCDs by one-third by 2030 (Direktorat Pencegahan dan Pengendalian Penyakit, 2019).

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Hafizi et al., 2024; Yameny, 2024). Hyperglycemia may occur due to inadequate insulin production, insulin resistance, or a combination of these mechanisms (Rosdah et al., 2025). The condition develops progressively and can lead to severe microvascular and macrovascular complications if not adequately controlled (Arania et al., 2021). According to the International Diabetes Federation (IDF), approximately 589 million adults aged 20–79 years live with diabetes worldwide in 2024, representing nearly one in nine adults globally. This number is projected to increase to 853 million by 2050, highlighting the growing global burden of the disease (IDF, 2021).

Effective management of diabetes mellitus is crucial for reducing the risk of complications and improving the life expectancy of affected individuals (Tomic et al., 2022). Early diagnosis, regular monitoring, and long-term glycemic control are essential for diabetes management. Several risk factors contribute to the development of diabetes mellitus, including genetic predisposition, obesity, advancing age,

and unhealthy lifestyle. The risk of developing diabetes increases with age, particularly after 40 years, partly because of age-related declines in glucose tolerance and insulin sensitivity (Jumadewi et al., 2022).

The diagnosis and monitoring of diabetes mellitus rely on several laboratory-based assessments of blood glucose levels. Common clinical tests include fasting plasma glucose, random blood glucose, oral glucose tolerance test, and glycated hemoglobin (HbA1c) measurements. Blood glucose indicators are important biomarkers for assessing metabolic status and identifying disturbances in glucose homeostasis. While insulin resistance is commonly detected through impaired fasting glucose or glucose tolerance, long-term glycemic control is generally monitored using HbA1c levels (Warner et al., 2024). According to the World Health Organization (WHO), an HbA1c value of $\geq 6.5\%$ (48 mmol/mol) is one of the diagnostic criteria for diabetes mellitus and reflects the average blood glucose concentrations over the preceding two to three months (WHO, 2016; Yameny, 2024).

The increasing prevalence of diabetes mellitus is closely linked to lifestyle changes and the growing prevalence of overweight and obesity. Obesity is a well-established risk factor for type 2 diabetes mellitus (T2DM), the most common form of diabetes. Excess adipose tissue contributes to insulin resistance through multiple biological pathways, including chronic low-grade inflammation, oxidative stress, and dysregulation of adipokine secretion (Nasrulsyah et al., 2022). Excessive body weight suppresses insulin signaling pathways and promotes a progressive increase in blood glucose levels due to chronic nutrient overload (Ruze et al., 2023). Consequently, individuals with overweight or obesity face a substantially greater risk of developing T2DM and its associated complications.

Importantly, obesity is a modifiable risk factor that can be prevented through healthy lifestyle changes. Regular physical activity, balanced dietary intake, and weight management have consistently been shown to reduce the risk of diabetes mellitus and improve metabolic health outcomes (Dinas Kesehatan, 2019; Huriyati et al., 2019). Furthermore, routine fitness assessments and body composition measurements can facilitate the early identification of individuals at risk for metabolic

disorders. Strategies aimed at increasing muscle mass and reducing abdominal adiposity have beneficial effects on glucose metabolism and insulin sensitivity (Gifari et al., 2025). Previous studies have identified obesity as a central determinant of diabetes mellitus, particularly among urban populations undergoing rapid lifestyle transitions (Arbie et al., 2025).

Although obesity is widely recognized as a major determinant of diabetes mellitus, the contributions of other factors such as physical activity, smoking behavior, and family history remain inconsistent across populations and settings. Understanding the relative influence of these factors is important for developing effective prevention strategies tailored to the local context. Therefore, this study aimed to identify factors associated with the occurrence of diabetes mellitus, focusing on obesity, physical activity, smoking habits, and family history among patients attending the Clinical Pathology Laboratory of dr. Zainoel Abidin Regional General Hospital Banda Aceh.

Methods

This research was a quantitative study with a case-control design conducted at RSUD dr. Zainoel Abidin Banda Aceh, specifically in the pathology laboratory. This hospital was selected purposively because it functions as a primary referral hospital and a Type A education center. Specifically, it was carried out in the pathology laboratory area of RSUD dr. Zainoel Abidin because it is one of the gathering places for patients who are referred to examine themselves in the pathology laboratory for various reasons, including diabetes mellitus as a non-communicable disease whose number is increasing.

Data collection was conducted from January to August 2023 using secondary data and August using primary data. The study sample was obtained using the Slovin formula and purposive sampling technique, which included 23 individuals. Therefore, 23 individuals with diabetes and 23 individuals without diabetes were required as controls. The inclusion criteria were age ≥ 40 years, willingness to participate, diabetes or non-communicable diseases (NCDs), and undergoing examination at the study site.

Data collection was conducted through interviews and direct measurements by

researchers, assisted by five trained enumerators who completed the questionnaires and assessed the respondents' nutritional status. The interview instrument used a structured questionnaire to measure respondents' characteristics based on age, sex, current illnesses/diabetes mellitus, obesity, physical activity, smoking habits, and medical history.

The criteria for disease suffering/diabetes mellitus were determined based on a doctor's diagnosis. Obesity was measured using the BMI formula (kg/m^2) by measuring body weight and height (Olfert et al., 2018). Respondents were categorized as obese if their body weight exceeded a BMI of $\geq 25.00 \text{ kg/m}^2$; they were not obese if their BMI was $< 25 \text{ kg/m}^2$ (Nasrulsyah et al., 2022). Physical activity was measured using the International Physical Activity Questionnaire (IPAQ) (Patnaik et al., 2020).

Activities included work, travel, and leisure time activities calculated based on the length of time spent doing these types of activities, which were categorized into two groups: sufficient if > 150 minutes/day, and insufficient physical activity if < 150 minutes/day (Wungow et al., 2021). Smoking habits were assessed based on the presence or absence of smoking habits, and medical history was assessed based on the presence or absence of a family history of diabetes mellitus.

Data were analyzed using univariate and bivariate chi-square statistical tests with a significance level ($\alpha = 0.05$) or 95% confidence level (CL). This was followed by multivariate testing with multiple logistic regression testing to determine the most influential variables. This analysis is a mathematical modeling approach for analyzing the influence of several independent variables on dichotomous or binary categorical dependent variables. The variables included in the multiple logistic regression prediction model using the backward method included all variables in the model. This study was approved by the Research Ethics Committee of dr. Zainoel Abidin RSUD Banda Aceh, with permit number 157/ETIK-RSUDZA/2023.

Result and Discussion

Characteristics of Respondents

Figure 1 presents the distribution of the respondents' characteristics. The study included 46 participants, consisting of 23 patients with diabetes mellitus and 23 controls.

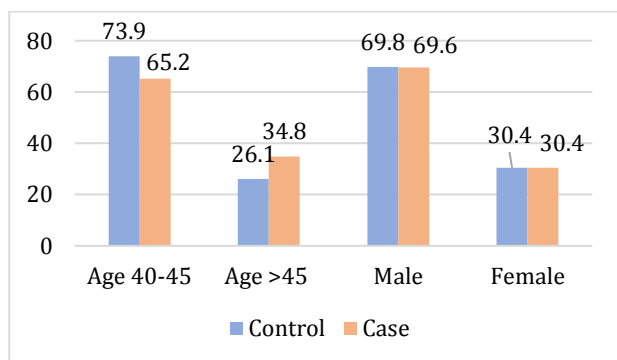


Figure 1. Characteristics of respondent based on primary data

As shown in Figure 2, most respondents were aged 40–45 years, accounting for 73.9% of the control group and 65.2% of the diabetes mellitus group. In terms of sex distribution, males represented the majority of the participants in both groups, accounting for 69.8% of the total sample.

The predominance of respondents aged ≥ 40 years is consistent with the established epidemiology of diabetes mellitus. Advancing age is a well-recognized risk factor for diabetes because physiological aging is associated with progressive declines in endocrine function, insulin sensitivity, and glucose metabolism (Sovia et al., 2020; Yusnanda et al., 2018). Age-related metabolic changes may contribute to impaired glucose tolerance and an increased susceptibility to diabetes mellitus.

In addition to age, family history is an important non-modifiable risk factor for diabetes mellitus. Individuals with a family history of diabetes are generally more likely to develop the disease because of shared genetic susceptibility and environmental factors. Previous studies have reported that increasing age and hereditary factors contribute substantially to the development of type 2 diabetes mellitus (Rahajeng, 2020). Furthermore, glucose intolerance tends to increase after the age of 40 years, thereby elevating the risk of diabetes mellitus in middle-aged and older adults (Jumadewi et al., 2022).

The demographic profile observed in this study reflects the population groups most vulnerable to diabetes mellitus and highlights the importance of targeted screening and preventive interventions among adults aged ≥ 40 years. Early identification of individuals at risk, particularly those with a family history of diabetes and other metabolic risk factors, may

contribute to reducing the disease incidence and preventing long-term complications.

Prevalence of Diabetes Mellitus

Data were obtained from the medical records of dr. Zainoel Abidin Regional General Hospital, Banda Aceh, between January and August 2023, are presented in Figure 1.

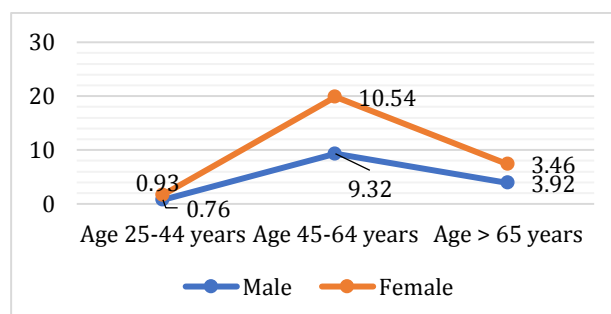


Figure 2. The prevalence of diabetes mellitus in dr. Zainoel Abidin Regional General Hospital based on secondary data

Figure 2 illustrates the prevalence of diabetes mellitus (DM) among patients attending dr. Zainoel Abidin Regional General Hospital, Banda Aceh during the study period. The data indicate that among individuals aged 25–45 years, the prevalence of diabetes mellitus was 0.76% in males and 0.93% in females. In the 45–65 years age group, the prevalence increased substantially to 9.32% among men and 10.54% among women. Among individuals older than 65 years, the prevalence was 3.92% in men and 3.46% in women. These findings suggest that diabetes mellitus was more prevalent among women aged 25–65 years, whereas among individuals older than 65 years, the prevalence was slightly higher in men than in women.

Based on hospital medical record data, diabetes mellitus accounted for approximately 5.9% of all recorded cases and ranked as the fifth most prevalent disease during the study period, with a higher proportion observed in women (Jumadewi et al., 2023). The highest prevalence was identified among women aged 45–64 years (10.54%). This pattern is consistent with previous evidence indicating that the burden of diabetes mellitus continues to increase globally and has become a major contributor to the growing prevalence of non-communicable diseases (NCDs), particularly in low- and middle-income countries (Anggraeni & Fauziah, 2020).

The increasing prevalence of diabetes mellitus is influenced by both modifiable and non-modifiable risk factors, including obesity, physical inactivity, unhealthy dietary habits, advancing age, and genetic predisposition (Handayani et al., 2023; Kemenkes RI, 2020). As one of the most significant NCDs worldwide, diabetes mellitus (DM) contributes substantially to morbidity and mortality and places a considerable burden on healthcare systems. According to global estimates, NCDs account for approximately 71% of all deaths worldwide, with the majority occurring in low- and middle-income countries (Direktorat Pencegahan dan Pengendalian Penyakit 2019). Consequently,

diabetes prevention and control remain important public health priorities in Indonesia and worldwide.

Association of Obesity, Physical Activity, Smoking Habits, and Family History with Diabetes Mellitus

Bivariate analysis using the chi-square test was performed to examine the associations between obesity, physical activity, smoking habits, family history, and the occurrence of diabetes mellitus (DM) among patients attending the Clinical Pathology Laboratory of dr. Zainoel Abidin Regional General Hospital Banda Aceh. The results are shown in Table 1.

Table 1. Bivariate analysis of determinants associated with diabetes mellitus (n = 46)

Determinants	Cases, n (%)	Controls, n (%)	p-value	OR (95% CI)
Obesity				
Yes	17 (73.9)	4 (17.4)	<0.001	13.458 (3.239–55.921)
No	6 (26.1)	19 (82.6)		
Physical activity				
Insufficient	14 (60.9)	12 (52.2)	0.766	0.701 (0.218–2.261)
Sufficient	9 (39.1)	11 (47.8)		
Smoking habits				
Yes	15 (65.2)	9 (39.1)	0.140	2.917 (0.879–9.674)
No	8 (34.8)	14 (60.9)		
Family history of diabetes				
Yes	9 (39.1)	4 (17.4)	0.189	3.054 (0.780–11.959)
No	14 (60.9)	19 (82.6)		

As shown in Table 1, obesity was substantially more prevalent among participants with diabetes mellitus (73.9%) than among those without (17.4%). The chi-square test revealed a significant association between obesity and diabetes mellitus ($p < 0.001$). The odds ratio indicated that obese individuals were approximately 13.5 times more likely to have diabetes mellitus than non-obese individuals (OR = 13.458; 95% CI: 3.239–55.921).

Insufficient physical activity was reported by 60.9% of participants in the diabetes group and 52.2% of participants in the control group, respectively. However, no statistically significant association was observed between physical activity and diabetes mellitus ($p = 0.766$). The estimated odds ratio (OR = 0.701; 95% CI: 0.218–2.261) also indicated no meaningful relationship between physical activity status and diabetes mellitus in the study population.

Regarding smoking habits, a higher proportion of participants with diabetes

reported smoking (65.2%) than those without diabetes (39.1%). However, this association was not statistically significant ($p = 0.140$). Although the odds ratio suggested increased odds of diabetes among smokers (OR = 2.917; 95% CI: 0.879–9.674), the confidence interval included unity, indicating insufficient evidence of a significant association between smoking and diabetes.

Similarly, a family history of diabetes was more common in the diabetes group (39.1%) than in the control group (17.4%). However, no statistically significant association was found between family history and diabetes mellitus ($p = 0.189$). The estimated odds ratio was 3.054 (95% CI: 0.780–11.959), suggesting a possible increase in risk that did not achieve statistical significance.

Overall, the findings demonstrated that obesity was the only variable significantly associated with diabetes mellitus. Previous

epidemiological studies have identified both non-modifiable factors, such as age and genetic predisposition, and modifiable factors, including obesity and physical activity, as important determinants of diabetes mellitus (Al Rahmad, 2021; Nasrulsyah et al., 2022). The absence of a significant association between physical activity and diabetes in the present study may be attributable to the measurement limitations. Physical activity data were self-reported, and participants may have experienced difficulty accurately recalling the duration and intensity of their activity. Such recall bias may have reduced the accuracy of the exposure classification and attenuated the observed association. This finding differs from those of previous studies that reported that regular physical activity

contributes to improved glycemic control and reduced risk of diabetes (Subhan et al., 2025).

Determinants of Diabetes Mellitus

Multivariate analysis was conducted using multiple logistic regression to identify the most influential determinants of diabetes mellitus. Variables with p-values <0.25 in the bivariate analysis were included in the initial model. The backward elimination method was subsequently applied to determine the final model by sequentially removing variables with the weakest contributions while retaining theoretically relevant factors. Accordingly, obesity, smoking habits, and family history met the inclusion criteria, whereas physical activity (p = 0.766) was excluded from the multivariable analysis.

Table 2. Multiple logistic regression analysis of factors associated with diabetes mellitus

Variables	B	SE	Wald	p-value	Adjusted OR (Exp(B))	95% CI
Obesity	3.136	0.9	12.14	0.001	23.02	3.94–134.40
Smoking	1.41	0.899	2.46	0.116	4.1	0.71–23.73
Family history of diabetes	1.228	0.916	1.8	0.18	3.41	0.57–20.56
Constant	-2.506	0.866	8.38	0.004	0.08	–

Model fit: Nagelkerke R² = 0.48; Hosmer–Lemeshow test p = 0.721.

Multivariate analysis identified obesity as the strongest determinant of diabetes mellitus. Obesity remained significantly associated with diabetes after adjusting for smoking habits and family history (p = 0.001). The adjusted odds ratio indicated that obese individuals had approximately 23 times higher odds of developing diabetes mellitus than non-obese individuals (AOR 23.02 [95% CI 3.94–134.40]).

In contrast, smoking habits and family history of diabetes were not independently associated with diabetes mellitus after adjustment for other variables, as indicated by p-values greater than 0.05. Although their adjusted odds ratios suggest elevated risks, the wide confidence intervals and lack of statistical significance indicate considerable uncertainty regarding these associations.

The present study demonstrated that obesity was significantly associated with diabetes mellitus among patients attending the Clinical Pathology Laboratory of dr. Zainoel Abidin Regional General Hospital Banda Aceh. Both bivariate and multivariate analyses consistently identified obesity as the strongest determinant of diabetes mellitus.

Obesity is characterized by excessive accumulation of body fat that impairs metabolic function and increases insulin resistance, thereby contributing to the development of type 2 diabetes mellitus (T2DM). These findings are consistent with those of previous studies that reported a strong association between obesity and diabetes risk (Chandrasekaran & Weiskirchen, 2024; Saidah et al., 2023; Pakpahan et al., 2024). Excess adiposity promotes chronic low-grade inflammation, dysregulation of adipokine secretion, and impaired insulin signaling, all of which contribute to the pathogenesis of T2DM.

Obesity is a major global public health concern. National survey data indicate a continuous increase in the prevalence of obesity across different age groups in Indonesia (Risksedas, 2018). The growing prevalence of obesity has important implications for diabetes prevention because obesity substantially increases the risk of diabetes-related complications, including chronic kidney disease, coronary heart disease, peripheral neuropathy, diabetic foot ulcers and lower limb amputation (Akmal et al., 2025; Pratiwi et al., 2025; Rahman et al., 2022).

The present findings are also consistent with previous studies conducted in Aceh, which identified obesity as a significant predictor of diabetes mellitus among civil servants and other adult populations (Al Rahmad 2021; Nasrulsyah et al. 2022). The adjusted odds ratio obtained in this study further emphasizes the substantial contribution of obesity to the risk of diabetes in the local population.

Importantly, obesity is a modifiable risk factor for several diseases. Lifestyle interventions involving dietary modifications, increased physical activity, and weight management have consistently demonstrated effectiveness in reducing diabetes risk and improving glycemic control (Alkharis et al., 2025; Hariawan et al., 2020; Kemenkes RI, 2020). Nutritional interventions emphasizing balanced diets, increased dietary fiber intake, and improved self-management practices have been shown to reduce body mass index and improve blood glucose regulation in individuals with T2DM (Gyda et al., 2025; Puspaningtyas et al., 2024; Sutrisna et al., 2025).

Therefore, comprehensive diabetes management should integrate pharmacological treatment, healthy lifestyle modifications, regular monitoring of blood glucose levels, and patient-centered self-management strategies. Complementary approaches, including psychosocial and spiritual support, may also contribute to improved quality of life and treatment adherence among individuals living with diabetes mellitus (Antoni et al., 2025; Yameny, 2024).

Unlike obesity, smoking habits and family history were not significantly associated with diabetes mellitus in this study. These findings differ from those of previous studies that reported significant relationships between smoking, family history, and diabetes risk (Saidah et al., 2023). Several factors may explain these differences. First, the relatively small sample size may have limited statistical power to detect significant associations between variables. Second, the study population predominantly comprised individuals aged 45 years or younger, potentially reducing the observable influence of cumulative smoking exposure and hereditary risk factors. Consequently, larger studies with more diverse populations are required to clarify these relationships.

This study has several limitations. This study was conducted at a single center and

involved a relatively small sample size, which may limit the generalizability of our findings. Furthermore, physical activity was assessed using self-reported measures, which are susceptible to recall bias and misclassification errors. Future studies should incorporate larger multicenter samples, objective measurements of physical activity and obesity, and longer observation periods to provide more robust evidence regarding the determinants of diabetes mellitus.

Conclusion

This case-control study demonstrated that obesity was significantly associated with the occurrence of diabetes mellitus among patients attending the Dr. Zainoel Abidin Regional General Hospital Banda Aceh. Obese individuals had substantially higher odds of developing diabetes mellitus than non-obese individuals, indicating that obesity is a major modifiable determinant of the disease in this population. In contrast, physical activity, smoking habits, and family history of diabetes were not significantly associated with diabetes mellitus in the present study.

These findings highlight the importance of obesity prevention and weight management strategies in diabetes prevention programs. Regular monitoring of body mass index (BMI), promotion of healthy dietary practices, increased physical activity, and routine health screening should be strengthened, particularly among adults aged ≥ 40 years. Early identification and management of obesity may reduce the burden of diabetes mellitus and its associated complications. Future studies involving larger and more diverse populations are recommended to further investigate the roles of behavioral, genetic, and environmental factors in the development of diabetes mellitus.

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