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Assessing Glycemic Control through Glycated Hemoglobin a 1c (HbA1c) and Body Mass Index (BMI) indicators: A Retrospective Study of Type II Diabetic Patients at King Salman Armed Forces Hospital Tabuk Saudi Arabia 2025

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ABSTRACT

Background: Poor glycemic control in patients with type 2 diabetes mellitus (T2DM) is a major public health concern, with obesity being a significant contributing factor. Understanding the relationship between body mass index (BMI) and glycemic control may help guide targeted interventions.

Objectives: This study aimed to assess glycemic control using glycated hemoglobin (HbA1c) and BMI, and to evaluate the association between BMI and suboptimal glycemic control among adult patients with T2DM attending King Salman Armed Forces Hospital in Tabuk, Saudi Arabia.

Methods: A retrospective observational study was conducted among 415 adult T2DM patients (≥18 years) between July and October 2025. Demographic data, BMI, HbA1c, fasting blood glucose (FBS), and random blood glucose (RBS) were extracted from medical records. Descriptive statistics, Pearson's correlation, one-way ANOVA, and linear regression analyses were performed, with statistical significance set at $p < 0.05$.

Results: The mean age of participants was 59.6 ± 15.3 years, with females representing 56.7% of the sample. The mean HbA1c was 8.2 ± 2.1%, with only 32.5% achieving the target level (<7%). The mean BMI was 30.7 ± 7.5 kg/m², with 43% classified as obese (BMI ≥30 kg/m²). Significant positive correlations were observed between BMI and HbA1c ($r = 0.42$, $p < 0.001$), FBS ($r = 0.38$, $p < 0.001$), and RBS ($r = 0.35$, $p < 0.001$). Regression analysis showed that each 1 kg/m² increase in BMI was associated with a 0.08% increase in HbA1c ($R^2 = 0.18$, $p < 0.001$). The BMI–HbA1c correlation was stronger among females ($r = 0.44$) than males ($r = 0.39$), and females had significantly higher mean HbA1c values ($p = 0.012$).

Conclusion: Higher BMI was significantly associated with poorer glycemic control among T2DM patients, with the association being more pronounced in females. Targeted weight management interventions, especially for women with obesity, are recommended to improve glycemic outcomes.

Keywords: *Type 2 diabetes mellitus, body mass index, HbA1c, glycemic control, obesity, Saudi Arabia.*

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1. INTRODUCTION

Diabetes is a significant public health concern and one of the four main noncommunicable diseases that global leaders are prioritizing. The incidence and prevalence of diabetes have been steadily increasing over the past several decades(1). Diabetes is a leading cause of death, characterized by elevated blood glucose levels that significantly contribute to severe complications, such as cardiovascular diseases and kidney failure (2). This has led to considerable economic losses for individuals, families, health systems, and national economies(1).

Hyperglycemia occurs when the pancreas fails to produce insulin efficiently and the cells in our body become resistant to insulin, a condition known as insulin resistance, leading to elevated blood sugar levels (3). This condition can be identified through specific methods, such as testing glucose concentration in venous plasma and analyzing glycated hemoglobin (HbA1c). HbA1c reflects average blood sugar levels over the past 2-3 months. Increased glucose levels and related markers indicate potential or persistent hyperglycemia(4). The American Diabetes Association advises keeping HbA1c levels under 7% to lower the risk of microvascular and macrovascular complications. Several factors, such as lifestyle, medications, and body composition, can influence HbA1c levels(5).

Excess body weight is strongly linked to decreased insulin sensitivity, which is associated with cardiovascular risk factors and is a key characteristic of type 2 diabetes (T2D). In fact, having a body mass index (BMI) of 25 kg/m² or higher, indicating overweight, is considered the primary risk factor for T2D.In individuals with type 2 diabetes (T2D), being overweight or obese is linked to poorer glycemic control. However, achieving modest and sustained weight loss has been shown to enhance glycemic control and reduce the need for glucose-lowering medications (6).

Project Objectives

- Assessing Glycemic Control through Glycated Hemoglobin a 1c (HbA1c) and Body Mass Index (BMI) indicators
- To evaluate the association between increased body mass index (BMI) and having suboptimal glycemic control in patients with Type 2 Diabetes mellitus.

Literature Survey/Background

Diabetes mellitus (DM) has seen a dramatic increase worldwide over the past two decades, and this trend is expected to continue for the next 20 years. In 2021, around 537 million adults aged 20 to 79 were living with diabetes, which represents about 10.5% of the global adult population. That year, diabetes was responsible for approximately 6.7 million deaths globally. (1). By the year 2030, it is estimated that 643 million adults will have diabetes, and this number could rise to 783 million by 2045, meaning that 1 in 8 adults will be affected by the condition. (7). According to the International Diabetes Federation, approximately 483 million people worldwide have type 2 diabetes, accounting for 90% of all diabetes cases. Furthermore, it is estimated that between 20% and 30% of individuals with type 2 diabetes are in more advanced stages of the disease and require insulin treatmen(8)t. There is a Cross-Sectional Study From the Kingdom of Saudi Arabia assessed the Glycemic Control through Glycated Hemoglobin a 1c (HbA1c) showed the majority of the participants (65%) were found to have poor glycemic control(9). Diabetes is a leading cause of death characterized by high blood glucose levels (2) . If not controlled, it may lead to complications for patients that could be prevented or delayed. (3). The disease can be diagnosed and monitored through blood glucose tests and/or glycated hemoglobin (HbA1c) testing. HbA1c provides information about long-term hyperglycemia over the past 2–3 months. It helps predict the risk of diabetic complications and assesses glycemic control, allowing for better understanding of the risk of complications in diabetic patients. (10) . body mass index (BMI) is a straightforward measure of body fat that is calculated based on an individual's weight and height. It is strongly associated with insulin resistance and glycemic control(11).Numerous studies have shown that an increased BMI is a significant risk factor for poor glycemic control in patients with type 2 diabetes mellitus (T2DM). Obesity worsens insulin resistance, which leads to elevated blood glucose levels and higher levels of HbA1c. On the other hand, weight loss in overweight and obese individuals is linked to improved insulin sensitivity and reductions in HbA1c levels. (12). The study will Assessing Glycemic Control through Glycated Hemoglobin a 1c (HbA1c) and Body Mass Index (BMI) indicators and to evaluate the association between increased body mass index (BMI) and having suboptimal glycemic control in patients with Type 2 Diabetes mellitus.

2. METHODS

Study Design and Setting

This retrospective observational study was conducted at King Salman Armed Forces Hospital in Tabuk, Saudi Arabia, from July to October 2025. The hospital is a tertiary care center serving a wide catchment area in the northern region of the country.

Study Population

The study population consisted of adult patients diagnosed with type 2 diabetes mellitus (T2DM) who attended the Endocrinology or Clinical Nutrition Departments prior to July 2025. Eligibility criteria included:

- **Inclusion criteria:** Patients aged ≥18 years, both males and females, residing in the Tabuk region, and having at least one documented HbA1c measurement within the study period.
- **Exclusion criteria:** Patients with type 1 diabetes mellitus, pregnant women, children or adolescents, and individuals residing outside the Tabuk region.

Sample Size Determination

The sample size was calculated using the Raosoft® online calculator, assuming a total T2DM population of 2,000 patients, an estimated prevalence of suboptimal glycemic control of 50%, a 5% margin of error, and a 95% confidence level. The calculated sample size was 377, which was increased by 10% to account for potential missing data, yielding a final target of 415 participants. This sample size ensured a statistical power of approximately 80% to detect significant associations.

Data Collection and Variables

Data were extracted from the hospital's electronic medical record (EMR) system by trained data collectors using a standardized data collection form. Extracted variables included:

- **Sociodemographic data:** age, gender, nationality, and place of residence.
- **Anthropometric measurements:** weight, height, and body mass index (BMI, kg/m²).
- **Glycemic control indicators:** glycated hemoglobin (HbA1c, %), fasting blood glucose (FBS, mmol/L), and random blood glucose (RBS, mmol/L).

For quality assurance, data completeness and accuracy were verified by a second reviewer.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 22. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) as appropriate. Categorical variables were summarized as frequencies and percentages.

- **Comparisons:** Independent t-test or Mann–Whitney U test for continuous variables; Chi-square test for categorical variables.
- **Correlations:** Pearson's correlation coefficient (r) to assess the relationship between BMI and glycemic indicators.
- **Group comparisons:** One-way analysis of variance (ANOVA) with post-hoc Tukey tests to compare HbA1c across BMI categories.
- **Regression analysis:** Simple linear regression to estimate the effect of BMI on HbA1c. Assumptions of normality and homogeneity of variance were tested using the Shapiro–Wilk and Levene's tests, respectively. Statistical significance was set at $p < 0.05$.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of King Salman Armed Forces Hospital (Approval No. [KSAFH-RET-2025-652]). All data were anonymized prior to analysis to ensure patient confidentiality, and the study complied with the Declaration of Helsinki ethical principles.

3. RESULTS

This section presents the statistical analysis of the collected data, describing the demographic characteristics of the study participants, glycemic control indicators, and body mass index (BMI) distribution. It also examines the associations between BMI and glycemic control parameters, including glycated hemoglobin (HbA1c), fasting blood glucose (FBS), and random blood glucose (RBS), using Pearson's correlation coefficients, one-way analysis of variance (ANOVA), and linear regression models. Gender-based differences in BMI and HbA1c were also assessed. Statistical significance was considered at a p-value of less than 0.05.

Table 1. Demographic Characteristics of the Study Population (N = 415)

Variable	Value
Age (years)	
Mean ± SD	59.6 ± 15.3

Variable	**Value**
Range	17 – 92
Gender	
Female	56.7%
Male	43.3%
Nationality	
Saudi	99.2%
Non-Saudi	0.8%
Residence	
Tabuk region	100%

This table summarizes the demographic distribution of participants, showing that the majority were female, Saudi nationals, with a mean age close to 60 years, and all residing in the Tabuk region.

Table 2. Glycemic Control Indicators

Indicator	**Mean ± SD**	**Category**	**Percentage**
HbA1c (%)	8.2 ± 2.1	<7% (Good control)	32.5%
		7–9% (Moderate)	45.8%
		>9% (Poor control)	21.7%
FBS (mmol/L)	8.4 ± 3.2	—	—
RBS (mmol/L)	9.1 ± 4.3	—	—

Less than one-third of patients achieved the target HbA1c level (<7%), with most patients falling in the moderate or poor glycemic control categories.

Table 3. Distribution of Body Mass Index (BMI) Categories

Category	**Percentage**
Underweight (<18.5)	3.1%
Normal weight (18.5–24.9)	22.4%
Overweight (25–29.9)	31.6%
Obesity class I (30–34.9)	24.8%
Obesity class II (35–39.9)	12.1%
Morbid obesity (≥40)	6.0%

The majority of participants (43%) were classified as obese (BMI ≥30 kg/m²), supporting the study's hypothesis of a link between excess body weight and poor glycemic control.

Table 4. Correlation Between BMI and Glycemic Control Indicators

Indicator	Pearson’s r	p-value
HbA1c	0.42	<0.001
FBS	0.38	<0.001
RBS	0.35	<0.001

Positive and statistically significant correlations were observed between BMI and all glycemic control indicators, suggesting that higher BMI is associated with higher blood glucose levels.

Table 5. Mean HbA1c Levels by BMI Category

BMI Category	HbA1c (Mean ± SD)
Underweight	7.1 ± 1.2
Normal	7.5 ± 1.5
Overweight	8.0 ± 1.8
Obesity class I	8.6 ± 2.1
Obesity class II	9.2 ± 2.4
Morbid obesity	9.8 ± 2.7
p-value (ANOVA)	<0.001

Mean HbA1c increased progressively across higher BMI categories, with statistically significant differences between groups.

Table 6. Linear Regression Analysis for Predicting HbA1c Based on BMI

Parameter	Coefficient	p-value
Intercept	5.8	<0.001
BMI	0.08	<0.001
R^2	0.18	—

The regression model indicates that each 1 kg/m² increase in BMI is associated with an estimated 0.08% increase in HbA1c.

Table 7. Gender-Based Comparison of BMI and HbA1c

Indicator	Males (n=180)	Females (n=235)	p-value
BMI (kg/m²)	29.8	31.4	—
HbA1c (%)	8.0	8.4	0.012
r (BMI–HbA1c)	0.39	0.44	<0.001

The correlation between BMI and HbA1c was stronger in females, and mean HbA1c was significantly higher in females compared to males.

4. CONCLUSION

This retrospective observational study examined the relationship between body mass index (BMI) and glycemic control, as assessed by glycated hemoglobin (HbA1c), among adult patients with type 2 diabetes mellitus (T2DM) attending King Salman Armed Forces Hospital in Tabuk, Saudi Arabia. The findings revealed that the study cohort had a mean age of 59.6 years, with a predominance of females (56.7%) and almost all participants being Saudi nationals (99.2%). The majority of patients exhibited suboptimal glycemic control, with only 32.5% achieving the target HbA1c level of <7%, while 45.8% had moderate control and 21.7% demonstrated poor control (HbA1c >9%).

The mean BMI of the cohort was 30.7 kg/m², placing the average participant in the obese category, with 43% classified as having obesity grades I–III. Statistical analysis demonstrated a significant positive correlation between BMI and all glycemic control indicators (HbA1c, FBS, and RBS), with Pearson's correlation coefficients ranging from 0.35 to 0.42 ($p < 0.001$). Notably, patients with obesity exhibited substantially higher HbA1c levels compared to those with normal weight. Regression analysis indicated that each 1 kg/m² increase in BMI was associated with an estimated 0.08% increase in HbA1c. The association between BMI and HbA1c was more pronounced in females ($r = 0.44$) than in males ($r = 0.39$), and the mean HbA1c was significantly higher among females ($p = 0.012$).

These results underscore the substantial impact of excess body weight on glycemic control in T2DM patients, with implications for targeted weight management interventions as a critical component of diabetes care in this population.

5. RECOMMENDATION

Based on the study findings, the following recommendations are proposed:

1. **Integrate Structured Weight Management Programs:** Implement comprehensive weight reduction interventions, particularly for patients with BMI ≥30 kg/m², to improve insulin sensitivity and glycemic control.
2. **Targeted Interventions for High-Risk Groups:** Given the stronger association between BMI and HbA1c in females, specialized lifestyle modification programs tailored to women with obesity and T2DM should be prioritized.
3. **Routine Monitoring of Glycemic Control:** Strengthen clinical protocols for regular HbA1c assessment, especially in patients with obesity, to facilitate timely therapeutic adjustments.
4. **Intensive Management for Severe Obesity:** evelop intensive, multidisciplinary weight management plans—including medical nutrition therapy, physical activity promotion, and pharmacological or surgical options—for patients with BMI ≥35 kg/m².
5. **Expand Future Research:** Conduct longitudinal, multicenter studies incorporating additional variables such as disease duration, medication regimens, dietary patterns, and physical activity to better establish causal relationships and enhance generalizability.

6. LIMITATIONS

This study is limited by its cross-sectional design, which precludes causal inference, and by its single-center setting, which may restrict external validity. Additionally, the absence of data on important covariates, including duration of diabetes, pharmacological treatments, and physical activity, limits the scope of interpretation.

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