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# Correlations Among BMI, HbA1c, and TyG Index in Type 2 Diabetes Mellitus Patients

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**ABSTRACT**
Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by impaired glucose regulation. Body mass index (BMI) reflects nutritional status, glycated hemoglobin (HbA1c) indicates long-term glycemic control, and the triglyceride-glucose (TyG) index serves as a surrogate marker of insulin resistance. However, evidence regarding the relationships among these parameters in Indonesian patients with T2DM remains limited, particularly in North Jakarta. This study aimed to examine the correlations between BMI and HbA1c, HbA1c and the TyG index, and BMI and the TyG index in patients with T2DM at Hospital X, North Jakarta. This retrospective cross-sectional observational study analyzed 75 medical records of T2DM outpatients treated from January to December 2025 using total sampling. BMI was classified according to Asia-Pacific criteria, while the TyG index was categorized using a cutoff of 4.66. Spearman's rank correlation was used, with statistical significance set at $p < 0.05$. The 95% confidence intervals (CIs) were estimated using percentile bootstrap resampling with 5,000 samples. Most patients were female (53.3%), aged 45–54 years (33.3%), and had a T2DM duration exceeding five years (80.0%). Poor glycemic control (HbA1c >8.0%) was observed in 73.3% of patients. BMI showed a weak positive correlation with HbA1c ($r_s$= 0.256, p = 0.027; 95% bootstrap CI: 0.023–0.464). HbA1c also showed a weak positive correlation with the TyG index ($r_s$ = 0.258, p = 0.025; 95% bootstrap CI: 0.039–0.453). However, BMI was not significantly correlated with the TyG index ($r_s$ = 0.006, p = 0.961; 95% bootstrap CI: −0.218–0.237). In conclusion, BMI and the TyG index were each weakly associated with HbA1c, whereas BMI was not significantly associated with the TyG index. These findings indicate associations rather than causal relationships and suggest that BMI should not be used as the sole indicator of glycemic control.
***Keyword:*** *Type 2 Diabetes Mellitus; Body Mass Index (BMI); HbA1c; TyG Index; Glycemic Control.*

## Introduction

Noncommunicable diseases (NCDs) are the leading cause of mortality in Indonesia. The World Health Organization reported that NCDs caused more than 43 million deaths globally in 2021, of which nearly 18 million occurred in the productive age group (under 70 years) (WHO, 2025). Diabetes mellitus is one of the NCDs showing a concerning increase in Indonesia, with a current prevalence of 11.7% that is projected to rise to 16.09% by 2045 without adequate intervention (Kemenkes, 2023). Type 2 diabetes mellitus (T2DM) accounts for most cases of diabetes. The 2023 Indonesian Health Survey reported that T2DM represented 47.9% of diabetes cases, far exceeding the 18.1% attributed to type 1 diabetes. The

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burden is expected to grow with modern lifestyle changes, urbanization, and rising obesity (Kemenkes, 2023).

Obesity, commonly assessed by body mass index (BMI), is a major risk determinant for insulin resistance and poor glucose regulation (Guli et al., 2025). In Indonesia, the prevalence of obesity rose from 10.5% in 2007 to 21.8% in 2018, reached 18.5% among adults aged 18 years and above in 2024, and was projected at 20.8% for DKI Jakarta in 2024 (Kemenkes, 2023).Obesity in individuals with T2DM has been associated with an adverse cardiovascular risk profile (Daousi et al., 2023) and with a range of other metabolic and non-metabolic complications (Eibl G, 2023). This escalation is important because obesity not only increases the likelihood of T2DM but may also impair long-term glycemic regulation.

The management of all patients with diabetes aims to achieve optimal glucose control in order to prevent macro- and microvascular complications (Goh et al., 2021). Long-term glycemic control in patients with T2DM can be evaluated using HbA1c (glycated hemoglobin), fasting blood glucose, and postprandial glucose measurements. An elevated HbA1c level indicates poor glycemic control. A previous study at a health facility in Surabaya reported that, on average, 73.7% of the diabetic cohort had uncontrolled HbA1c values, indicating that most patients remain far from optimal glycemic targets and are therefore exposed to prolonged microvascular and macrovascular risk (Permatasari & Artanti, 2025).

Findings on the relationship between BMI and glycemic parameters among T2DM patients remain inconsistent across settings. Some studies found no significant relationship between BMI and blood glucose, such as a study at RSUD Dr. Drajat Prawiranegara ($p = 0.248$) (Lee et al., 2023) and a study on random blood glucose (Anjaswari, 2025), whereas other studies reported that obese patients had significantly higher HbA1c or fasting glucose than non-obese patients ($p = 0.031$) (Tinangon et al., 2025; Sevia Dwi Suryanti et al., 2024). This inconsistency, together with the limited number of Indonesian studies that jointly examine BMI, HbA1c, and the TyG Index—an emerging and more accessible surrogate marker of insulin resistance that requires only routine fasting triglyceride and glucose measurements—represents a clear knowledge gap, particularly for outpatient T2DM populations in North Jakarta. The novelty of this study lies in simultaneously evaluating these three metabolic relationships (BMI–HbA1c, HbA1c–TyG, and BMI–TyG) within a single North Jakarta outpatient cohort, providing local evidence beyond previous Indonesian studies that examined these parameters only in isolation. Accordingly, this study aimed to describe the sociodemographic and clinical characteristics of T2DM patients and to examine the correlations between BMI and HbA1c, between HbA1c and the TyG Index, and between BMI and the TyG Index, among T2DM patients at Hospital X, North Jakarta.

## Methods

This study employed an analytical observational design with a cross-sectional approach using retrospective medical record data from patients with type 2 diabetes mellitus at Hospital X, North Jakarta, during January–December 2025, comprising sex, age, anthropometric measurements, and laboratory profiles of metabolic indicators. Data collection, processing, and analysis were carried out from February to April 2026. Total sampling was applied by including all medical records that met the predetermined inclusion and exclusion criteria. A total of 75 patient medical records were included in the analysis.

This study used a total sampling (complete enumeration), in which all patients who met the inclusion criteria during the study period were included. Total sampling is appropriate when the eligible population is relatively limited and when the study aims to minimize sampling error (Hardani et al., 2020). The inclusion criteria were patients with a physician diagnosis of T2DM receiving outpatient care, patients who underwent HbA1c examination, and patients whose body weight and height were recorded. The exclusion criteria were patients with type 1 or gestational diabetes and patients with incomplete or disrupted medical records (missing patient identity, disease history, examination results, or physician/nurse verification). Records with missing or inconsistent data were excluded rather than imputed, yielding a final sample of 75 medical records. Data on body mass index (BMI), glycated hemoglobin (HbA1c), and triglyceride levels were obtained from patients' medical records during the study period. These measurements were not necessarily performed on the same date; therefore, the recorded values were collected according to their availability in the medical records. This study was reviewed and approved by the Health Research Ethics Committee of Universitas 17 Agustus 1945 Jakarta (Approval Number: No.190/KEPK-UTA45JKT/EC/EXP/2/2026, dated: 11 February 2026), and permission to collect data was obtained from Hospital X, North Jakarta. Because only anonymized secondary medical-record data were used, patient confidentiality was maintained throughout, and the data were used solely for this research.

## Measurement of Metabolic Parameters

Clinical laboratory results were extracted from the medical records of patients diagnosed with T2DM. Body mass index (BMI) was calculated by dividing body weight in kilograms by the square of height in meters (kg/m²). BMI was classified according to the Asia-Pacific classification into underweight (<18.5 kg/m²), normal (18.5–22.9 kg/m²), overweight (23.0–24.9 kg/m²), obesity class I (25.0–29.9 kg/m²), and obesity class II (≥30.0 kg/m²) (Kemenkes, 2025). HbA1c was classified into three categories of glycemic control: good (<6.5%), moderate (6.5–8.0%), and poor (>8.0%). Fasting blood glucose values were interpreted as an indicator of glycemic status (Kardika, 2019). The triglyceride-glucose (TyG) index

was calculated as ln [fasting triglycerides (mg/dL) × fasting plasma glucose (mg/dL)]/2. A TyG value of ≥4.66 was used to categorize elevated TyG values based on a previously published study. This threshold was used as an operational categorization criterion and should not be interpreted as a universal diagnostic threshold for insulin resistance (Aman et al., 2021). All anthropometric (body weight and height) and laboratory values (HbA1c, fasting blood glucose, and fasting triglycerides) were the most recent values recorded in each patient's medical record during the observation period, with glucose and lipid parameters obtained under fasting conditions.

**Data Analysis**

Data were collected using a laboratory data collection form. Univariate analysis was presented as frequency distributions. The normality of the data was assessed using the Kolmogorov–Smirnov test (Sianturi, 2025), which yielded $p < 0.001$ for BMI, $p = 0.062$ for the TyG Index, and $p = 0.200$ for HbA1c. Because at least one variable (BMI) was not normally distributed ($p < 0.05$), the overall distribution was treated as non-normal, and bivariate analysis was performed using the nonparametric Spearman's rho test. Spearman's rank correlation was used to assess associations between the study variables. Two-sided p-values below 0.05 were considered statistically significant. A 95% confidence interval for each correlation coefficient was estimated using percentile bootstrap resampling with 5,000 samples. Potential confounding factors, including age, sex, insulin regimen, medication adherence, dietary patterns, physical activity, disease duration, and comorbidities, were considered in interpreting the study findings. Although some of these variables were available in the medical records, they were not included in an adjusted statistical analysis. Information on medication adherence, dietary patterns, and physical activity was not consistently documented. Therefore, potential confounding effects could not be fully controlled, and residual confounding may have influenced the observed associations.

**Results and Discussion**

A study carried out at Hospital X, North Jakarta, involving 75 T2DM patients disclosed the following sociodemographic and clinical characteristics. According to Table 1, the predominant group of T2DM patients was female, comprising 40 individuals (53.3%), consistent with the 2023 Indonesian Health Survey, which reported a higher diabetes prevalence in women (2.7%) than in men (1.8%) (Kemenkes, 2023). This pattern has been linked to physiological factors, including a higher body-fat percentage and the decline of premenopausal estrogen, which increases the risk of insulin resistance and diabetes as women age. The predominant age group was 45–54 years at 33.3%, in line with previous Indonesian studies reporting that individuals aged over 45 years have a substantially higher risk of

T2DM, attributed to a reduced capacity to metabolize glucose with age (Susilawati & Rahmawati, 2021).

**Table 1. Sociodemographic characteristics**

| Sociodemographic characteristics | | n=75 | % |
|---|---|---|---|
| Gender | | | |
| 1. | Male | 35 | 46.7 |
| 2. | Female | 40 | 53.3 |
| Age | | | |
| 1. | 18-24 years old | 2 | 2.7 |
| 2. | 25-34 years old | 5 | 6.7 |
| 3. | 35-44 years old | 10 | 13.3 |
| 4. | 45-54 years old | 25 | 33.3 |
| 5. | 55-64 years old | 22 | 29.3 |
| 6. | 65-74 years old | 11 | 14.7 |

Table 2 presents the clinical characteristics of the patients. A large proportion—60 patients (80%)—had been diagnosed with T2DM for more than five which involves a gradual decline of pancreatic beta-cell function, insulin resistance, and lifestyle-related factors. Longer disease duration has been reported to increase the risk of T2DM complications (Susilawati & Rahmawati, 2021). Complications were documented in the medical records of 67 patients (89.3%). The complications recorded included diabetic neuropathy, diabetic retinopathy, and diabetic foot ulcers. Other comorbid conditions, including hypertension, dyslipidemia, and cardiovascular diseases, were recorded separately where applicable, these figures reflect complications actually recorded in the patient records rather than complications inferred from HbA1c or TyG values. For context, previous outpatient data reported a high burden of chronic T2DM complications, with 33.4% experiencing macrovascular and 34.7% microvascular complications (Purwandari et al., 2022).

Based on the Asia-Pacific BMI classification, a normal BMI was most common (22 patients 29.3%), and only 5.3% of patients were underweight. Most patients had poor glycemic control, with HbA1c > 8% in 55 patients (73.3%). Meanwhile, 14 patients (18.7%) had moderate control and 6 patients (8%) had good control. This finding is broadly consistent with an earlier Indonesian study in which most patients exhibited poor glycemic control (Yansen, 2023). A high TyG Index (≥ 4.66) was observed in 56 patients (74.7%). The TyG Index may be useful for identifying insulin resistance without requiring fasting insulin measurement. A concordance analysis comparing the TyG index with HOMA-IR reported a higher

frequency of insulin resistance among individuals with a TyG index ≥4.66 (Aman et al., 2021). The most frequent insulin regimen was a combination of rapid-acting and long-acting insulin, used by 65 patients (86.6%), consistent with previous reports (Rasdianah et al., 2023).

**Table 2. Clinical characteristics**

| Clinical characteristics | | n=75 | % |
|---|---|---|---|
| Duration of illness | | | |
| 1. | ≤5 years | 15 | 20 |
| 2. | >5 years | 60 | 80 |
| Complications | | | |
| 1. | None | 8 | 10.7 |
| 2. | Present | 67 | 89.3 |
| Body Mass Index (BMI) | | | |
| 1. | Underweight | 4 | 5.3 |
| 2. | Normal | 22 | 29.3 |
| 3. | Overweight | 14 | 18.7 |
| 4. | Obesity I | 20 | 26.7 |
| 5. | Obesity II | 15 | 20 |
| HbA1c level (glycemic control) | | | |
| 1. | Good control (<6.5%) | 6 | 8 |
| 2. | Moderate control (6.5–8%) | 14 | 18.7 |
| 3. | Poor control (>8%) | 55 | 73.3 |
| *Triglyceride-Glucose (TyG) Index* | | | |
| 1. | Normal | 19 | 25.3 |
| 2. | High | 56 | 74.7 |
| Insulin type | | | |
| 1. | Insulin Rapid Acting | 7 | 9.3 |
| 2. | Insulin Short Acting | 0 | 0 |
| 3. | Insulin Intermediate Acting | 0 | 0 |
| 4. | Insulin Long Acting | 2 | 2.7 |
| 5. | Pre-Mixed Combination | 1 | 1.3 |
| 6. | Combination | 65 | 86.7 |

Prior to the bivariate correlation analysis, a normality test was performed to determine whether the data were normally distributed. The Kolmogorov–Smirnov test produced $p < 0.001$ for BMI, $p = 0.062$ for the TyG Index, and $p = 0.200$ for

HbA1c. Because at least one variable was not normally distributed ($p < 0.05$), Spearman's rho was used for the bivariate analysis, as shown in Table 3.

**Table 3. Spearman Rho' Test**

| Variables | *Correlation Coefficient (r)* | *Sig. (2-Tailed) (p)* | *95% Bootstrap Cl* |
|---|---|---|---|
| BMI and HbA1c Levels | 0.256 | 0.027 | 0.023–0.464 |
| HbA1c Levels and the TyG Index | 0.258 | 0.025 | 0.039–0.453 |
| BMI and the TyG Index | 0.006 | 0.961 | −0.218–0.237 |

As shown in Table 3, Spearman's rank correlation analysis revealed a weak positive correlation between BMI and HbA1c ($r_s = 0.256$, $p = 0.027$, 95% bootstrap CI =0.023-0.464). This is consistent with a 2023 study by Bakri et al., which reported a significant association between the two variables ($p = 0.034$) (Bakri, 2023). According to the Indonesian Society of Endocrinology (PERKENI), overweight and obesity increase the risk of T2DM, because excess adipose tissue—particularly central obesity—induces insulin resistance, reducing the sensitivity of body cells to insulin and forcing the pancreas to work harder until its capacity to regulate blood glucose is impaired (PERKENI, 2021).

The correlation between HbA1c and the TyG Index was also significant ($r_s = 0.258$, $p = 0.025$, 95% bootstrap CI=0.039-0.453), indicating a weak positive association. This is consistent with a 2022 study reporting that a higher TyG Index score was associated with higher three-month average blood glucose (HbA1c) ($p < 0.001$) (Gedikli et al., 2022), and with further evidence of a significant positive correlation between the TyG Index and HbA1c, suggesting that the TyG Index may serve as an early indicator of glucose-metabolism abnormalities (Yunita et al., 2026). Although the strength of the correlation was weak, the statistically significant association indicates that higher TyG Index values tend to accompany higher HbA1c levels in this study population.

The correlation between BMI and the TyG Index yielded ($r_s = 0.006$, $p = 0.961$, 95% bootstrap CI =−0.218-0.237), indicating no significant association between the two variables. This is consistent with a previous study reporting that the TyG Index and BMI are not directly related (Kim et al., 2021).

It is important to note that although the association between BMI and HbA1c was statistically significant, its magnitude was weak ($r = 0.256$), indicating that BMI alone accounts for only a small proportion of the variability in HbA1c statistical significance should therefore not be equated with strong clinical significance. Because this study used a cross-sectional design based on secondary medical-record data, the observed associations reflect correlation rather than causation. Several

potential confounding factors may have influenced the observed relationships among BMI, HbA1c, and the TyG index. Treatment-related factors, including the type of glucose-lowering medication, insulin regimen, and insulin dose, may affect glycemic outcomes. Medication adherence is also important, as evidence indicates that better adherence to antidiabetic therapy is associated with improved glycemic control (Piragine et al., 2023; Ahmed et al., 2025 ). Furthermore, dietary patterns and physical activity may influence body weight, insulin sensitivity, and HbA1c levels. A recent systematic review and meta-analysis identified dietary non-adherence and physical inactivity as factors associated with inadequate glycemic control in patients with T2DM (Siddiquea et al., 2025). Longer disease duration may also contribute to poorer glycemic control because of the progressive nature of T2DM, while diabetic complications and comorbidities may increase treatment complexity and affect metabolic outcomes (Ahmed et al., 2025). However, these factors were not consistently available in the medical records and could not be statistically adjusted for in the present study. Therefore, residual confounding may have influenced the observed correlations, and the findings should be interpreted cautiously without inferring causal relationships.

Additional limitations include the retrospective single-center design, the relatively small sample size, and the possibility of missing or incompletely documented records, all of which limit the generalizability of the findings. Future prospective studies that account for these variables are needed to clarify the relationship between BMI and glycemic control. Another limitation of this study is that BMI, HbA1c, and triglyceride measurements were not necessarily obtained on the same date. Differences in the timing of these measurements may have influenced the interpretation of the relationships among the study variables.

**Conclusion**

This study found a weak positive correlation between body mass index (BMI) and HbA1c levels ($r_s = 0.256$, $p = 0.027$), as well as between HbA1c levels and the triglyceride-glucose (TyG) index ($r_s = 0.258$, $p = 0.025$). No statistically significant correlation was found between BMI and the TyG index ($r_s = 0.006$, $p = 0.961$). These findings indicate that BMI and the TyG index were each weakly associated with HbA1c in this study population, while BMI was not significantly associated with the TyG index. Given the cross-sectional design and weak correlation coefficients, the findings should be interpreted cautiously and do not establish causal relationships.

**Suggestion**

Given the significant association observed between HbA1c and the TyG Index, further prospective research is recommended to evaluate whether periodic

TyG Index screening could serve as a practical, cost-effective adjunct marker for metabolic evaluation in outpatients with T2DM. Future studies should also control for potential confounders and include larger, multicenter samples.

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