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Evaluating the Triglyceride–Glucose Index as an Early Screening Marker for Gestational Diabetes Mellitus

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is a significant risk factor for adverse short- and long-term health outcomes for both the mother and infant. Although the oral glucose tolerance test (OGTT) is the gold standard for diagnosing GDM, its reproducibility remains debated. This study assessed the predictive accuracy of the triglyceride–glucose (TyG) index as an early biomarker for GDM.

Methods: This prospective study was conducted at Al-Zahraa Teaching Hospital, Iraq, and included 150 singleton pregnant women at 7–14 weeks of gestation. Demographic and clinical data were collected. Maternal fasting blood tests were obtained for a lipid profile, fasting blood glucose, and HbA1c, and the TyG index was calculated. Predictive performance was evaluated using logistic regression and receiver operating characteristic (ROC) analysis.

Results: The TyG index was positively associated with incident GDM (OR = 3.45, 95% CI: 2.22–5.36; $p < 0.001$). ROC analysis showed an area under the curve (AUC) of 0.89, with a cut-off value of 8.5 yielding 85.0% sensitivity and 78.0% specificity.

Conclusion: An increased TyG index was significantly associated with the occurrence of GDM and may serve as an inexpensive tool for early screening.

Key words: Gestational diabetes mellitus; Triglyceride–glucose index; Insulin resistance; Pregnancy; Biomarkers

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INTRODUCTION

Gestational diabetes mellitus (GDM) has increased globally over the past decade, affecting approximately 10%–26% of pregnancies. This rise has been attributed in part to increasing maternal obesity and advanced maternal age [1].

GDM is associated with important short- and long-term adverse health outcomes for both mothers and their offspring, including an increased risk of type 2 diabetes, cardiovascular disease, and other metabolic disorders later in life [2]. The 75 g oral glucose tolerance test (OGTT) remains the gold standard for diagnosing GDM [3, 4].

However, the reproducibility of the OGTT remains debated; diagnostic criteria are not fully unified, and concerns persist regarding potential overdiagnosis, highlighting the need for additional credible biomarkers [5].

The triglyceride–glucose (TyG) index has been proposed as a reliable and cost-effective surrogate marker of insulin resistance (IR) [6]. Because IR is a key pathophysiological characteristic of metabolic syndrome and a precursor to type 2 diabetes, the TyG index may offer an accessible alternative to more complex traditional methods [7].

Nevertheless, the evidence on the TyG index as a screening tool for dysglycemia in pregnancy is contradictory. Some studies support its utility [7, 8], while others question its ability to predict GDM [9]. Therefore, this study aimed to investigate whether the TyG index could serve as an early biomarker of GDM.

PATIENTS AND METHODS

Study design and setting: A prospective analytic cohort study was conducted at Al-Zahraa Teaching Hospital. Enrollment and data collection were performed from October 1, 2024, to May 1, 2025.

A total of 150 women with singleton pregnancies were enrolled at their first antenatal (booking) visit at 7–14 weeks of gestation, during which only routine screening was performed. Exclusion criteria included pre-existing diabetes mellitus and chronic conditions such as hypertension, cardiovascular disease, and liver or kidney disease. Demographic and clinical data were collected, including maternal age and body mass index (BMI); obstetric history (gravidity, parity, previous abortions, and current gestational age); and relevant medical history (personal and family history of diabetes).

At the initial visit (7–14 weeks' gestation), venous blood samples were obtained from all participants after an overnight fast of at least 8 hours. Samples were analyzed for fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), and a fasting lipid profile (including triglycerides). Biochemical analyses were performed using standard automated enzymatic methods on a BIOLABO (France) analyzer. Internal quality control procedures were performed with each HbA1c measurement to ensure the reliability of results. The triglyceride–glucose (TyG) index was calculated for each participant using the following formula:

$$\text{TyG} = \ln [\text{TG (mg/dL)} \times \text{FPG (mg/dL)} / 2]$$

According to NICE guidelines, women were assessed for the risk of gestational diabetes mellitus (GDM) at the first antenatal appointment and categorized as either "moderate-risk" or "high-risk." High-risk was defined as a history of GDM in a prior pregnancy; these women were offered an oral glucose tolerance test (OGTT) as soon as possible, which was repeated at 24–28 weeks if the initial result was normal. Moderate-risk women, those with a BMI > 30, a previous macrosomic baby, a family history of diabetes, or belonging to a high-prevalence ethnic group, underwent an OGTT at 24–28 weeks [10].

Diagnosis of GDM: GDM was diagnosed according to RCOG/NICE guidelines using a 75 g oral glucose tolerance test (OGTT). Plasma glucose was measured at 0 (fasting) and 2 hours. GDM was diagnosed if one or both of the following thresholds were met or exceeded: fasting plasma glucose $\geq$ 5.6 mmol/L (100 mg/dL) and/or 2-hour plasma glucose $\geq$ 7.8 mmol/L (140 mg/dL) [10].

Follow-up: Participants were contacted by telephone up to 28 weeks of gestation to ensure completion of the recommended OGTT within the antenatal window.

Statistical analysis: Data were analyzed using SPSS (version 26). Continuous variables are presented as mean $\pm$ SD and categorical variables as *n* (%). Between-group differences were evaluated using Student's *t*-test or the χ^2 test, as appropriate. Spearman correlation coefficients were used to assess associations with OGTT values. Independent predictors of GDM were identified using multivariable logistic regression; results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). Receiver operating characteristic (ROC) analysis was used to determine the optimal TyG-index threshold (Youden index); the area under the curve (AUC), sensitivity, and specificity are reported. All tests were two-tailed with $\alpha = 0.05$.

RESULTS

Descriptive characteristics:

Women with GDM were significantly older (43.6 vs. 30.7 years, p=0.002) and had a higher BMI (34.1 vs. 29.3 kg/m^2, p<0.001) compared with non-GDM women. They also had higher gravidity (4.1 vs. 2.8, p=0.001) and parity (2.6 vs. 1.6, p=0.003).

Table 1. Baseline Characteristics and Laboratory Findings by Gestational Diabetes Mellitus (GDM) Status (N=150)

Variable	GDM (n=45)	Non-GDM (n=105)	p-value
Baseline characteristics			
Age (years)	43.6 ± 5.1	30.7 ± 4.9	**0.002**[a]
BMI (kg/m²)	34.1 ± 5.2	29.3 ± 4.7	**<0.001**[a]
Gravidity	4.1 ± 1.3	2.8 ± 1.4	**0.001**[a]
Parity	2.6 ± 1.2	1.6 ± 1.2	**0.003**[a]
Previous GDM, n (%)	24 (53.3%)	0 (0.0%)	**<0.001**[b]
Laboratory findings			
Fasting plasma glucose (mg/dL)	99.0 ± 1.4	81.7 ± 7.1	**<0.001**[a]
Triglycerides (mg/dL)	207.7 ± 17.2	65.9 ± 11.2	**<0.001**[a]
Total cholesterol (mg/dL)	283.6 ± 59.0	212.0 ± 49.5	**0.021**[a]
LDL (mg/dL)	123.0 ± 47.8	107.4 ± 45.3	0.093[a]
HDL (mg/dL)	47.3 ± 1.7	56.7 ± 11.5	**<0.001**[a]
HbA1c (%)	5.8 ± 0.4	4.8 ± 0.4	**<0.001**[a]
TyG index	9.24 ± 0.85	7.90 ± 0.18	**<0.001**[a]

Data are presented as mean ± SD or n (%).
[a]Independent-samples *t*-test. [b]χ^2 test.
Abbreviations: BMI, body mass index; GDM, gestational diabetes mellitus; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TyG, triglyceride–glucose index.

A history of previous GDM was present in 53.3% of women with GDM and was absent in the non-GDM group (p<0.001) (Table 1).

Laboratory findings:

The GDM group had significantly higher fasting plasma glucose (99.0 vs. 81.7 mg/dL, p<0.001), triglycerides (207.7 vs. 65.9 mg/dL, p<0.001), total cholesterol (283.6 vs. 212.0 mg/dL, p=0.021), and HbA1c (5.8 vs. 4.8%, p<0.001). HDL was significantly lower in the GDM group (47.3 vs. 56.7 mg/dL, p<0.001), whereas LDL levels showed no significant difference (123.0 vs. 107.4 mg/dL, p=0.093). The TyG index was markedly elevated in the GDM group (9.24 vs. 7.90, p<0.001) (Table 1).

Correlation analysis:

The TyG index demonstrated statistically significant positive correlations with OGTT glucose parameters at both the initial visit and at 24–28 weeks' gestation (all p<0.001). The strength of these correlations was consistently moderate to strong (Spearman's r range: 0.45–0.59), and correlations were marginally stronger at 24–28 weeks compared with the initial visit (Table 2, Panel A).

Predictors of GDM:

Multivariable logistic regression identified the TyG index as the strongest independent predictor of GDM (OR=3.45, 95% CI: 2.22–5.36, p<0.001). BMI (OR=1.26, p=0.001) and age (OR=1.06, p=0.004) were also significant predictors. HbA1c showed a trend toward association (OR=1.84, p=0.069) but did not reach statistical significance (Table 2, Panel B).

Predictive performance of TyG index:

The predictive performance of the TyG index for GDM was excellent, with an AUC of 0.89 (95% CI: 0.83–0.94, p<0.001). An optimal cut-off value of 8.5 was established, yielding a sensitivity of 85.0% and a specificity of 78.0% (Table 2, Panel C).

Table 2. Association and Predictive Performance of the Triglyceride–Glucose (TyG) Index for Gestational Diabetes Mellitus (GDM)

Panel A. Correlation of TyG index with OGTT glucose values (Spearman *r*; p-value)		
OGTT parameter	**Initial visit**	**24–28 weeks**
Fasting glucose	0.55 (< **0.001**)	0.59 (< **0.001**)
2-hour post-glucose	0.45 (<**0.001**)	0.48 (< **0.001**)

Panel B. Multivariable logistic regression for predictors of GDM				
Predictor	**OR**	**95% CI**	**p-value**	**VIF**
TyG index (ln scale)	3.45	2.22–5.36	< **0.001**	1.18
BMI (kg/m²)	1.26	1.11–1.43	**0.001**	1.22
Age (years)	1.06	1.02–1.10	**0.004**	1.15
HbA1c (%)	1.84	0.96–3.55	0.069	1.12

Panel C. ROC performance of TyG index for predicting GDM				
Cut-off point	**Sensitivity (%)**	**Specificity (%)**	**AUC (95% CI)**	**p-value**
8.5	85.0	78.0	0.89 (0.83–0.94)	< **0.001**

Panel A: Values are Spearman's correlation coefficient (*r*) with two-tailed p-values in parentheses.
Panel B: Multivariable model adjusted for TyG index, BMI, age, and HbA1c.
Panel C: TyG = ln[TG (mg/dL) × FPG (mg/dL) / 2]; ln = natural logarithm; cut-off optimized by maximum Youden index; PPV = 80.0%; NPV = 84.3%.
Abbreviations: AUC, area under the curve; BMI, body mass index; CI, confidence interval; FPG, fasting plasma glucose; GDM, gestational diabetes mellitus; HbA1c, glycated hemoglobin; OGTT, oral glucose tolerance test; OR, odds ratio; PPV, positive predictive value; NPV, negative predictive value; ROC, receiver operating characteristic; TG, triglycerides; TyG, triglyceride–glucose index; VIF, variance inflation factor.

DISCUSSION

Gestational diabetes mellitus (GDM) is characterized by glucose intolerance that first appears or is recognized during pregnancy and reflects impaired insulin secretion and/or increased insulin resistance. Women with GDM, particularly those with marked insulin resistance, have an increased risk of adverse maternal and neonatal outcomes [11]. Accordingly, identifying simple early pregnancy markers is clinically important. In this context, the triglyceride–glucose (TyG) index has been proposed as an early marker to predict subsequent GDM [8, 9, 11].

In the present study, women who developed GDM were significantly older (43.6 vs. 30.7 years, p=0.002) and had a higher BMI (34.1 vs. 29.3 kg/m², p<0.001) than women without GDM. These findings are consistent with previous reports identifying advanced maternal age and obesity as major risk factors for GDM [12–14]. This association may reflect age-related declines in β-cell reserve and progressive reductions in insulin sensitivity, which limit the ability to compensate for the physiological insulin resistance of pregnancy.

We also observed higher gravidity (4.1 vs. 2.8) and parity (2.6 vs. 1.6) among women with GDM. Although reproductive history may influence maternal metabolic status, previous studies (including Modzelewski et al.) suggest that parity is a weaker and less consistent predictor of GDM compared with age and obesity, which remain the dominant risk factors in most populations [15].

Regarding lipid metabolism, women with GDM had significantly higher triglyceride concentrations (207.7 ± 17.2 mg/dL vs. 65.9 ± 11.2 mg/dL) and lower HDL levels than controls. This pattern is consistent with earlier evidence linking dyslipidemia to insulin resistance and GDM [16–18]. Hypertriglyceridemia in GDM may be driven by increased hepatic very-low-density lipoprotein (VLDL) production and reduced lipoprotein lipase activity in the setting of insulin resistance [14].

Importantly, the TyG index emerged as a strong independent predictor of GDM in our multivariable model (OR = 3.45, 95% CI: 2.22–5.36; p<0.001). This finding aligns with prior studies reporting that TyG is an informative surrogate of insulin resistance and is associated with GDM risk [7, 19, 20]. Using a cut-off value of 8.5, the TyG index demonstrated good discriminative performance (AUC = 0.89, 95% CI: 0.83–0.94), with 85.0% sensitivity and 78.0% specificity. Variation in optimal TyG thresholds across studies is expected and may reflect differences in population characteristics, baseline metabolic risk, timing of measurement, and diagnostic criteria for GDM. For example, Mo et al. and Guo et al. reported cut-offs in the range of 8.632–8.890, whereas Yilmaz et al. reported a higher threshold of approximately 10.4 [7, 21, 22]. Despite this heterogeneity, several reports similarly describe good predictive accuracy of TyG for GDM [21, 23, 24]. In contrast, Guo et al. reported a lower predictive performance (AUC = 0.641), which may be attributable to differences in study design, population risk profile, or analytic methods [7].

CONCLUSION

The findings indicate that an elevated triglyceride–glucose (TyG) index is significantly associated with the development of gestational diabetes mellitus (GDM) and may serve as a simple, inexpensive tool for early risk stratification. Further studies in larger and more diverse populations are warranted to validate these results and to determine the optimal clinical cut-off for widespread implementation.

ETHICAL DECLARATIONS

- **Ethics Approval and Consent to Participate**

  The study protocol was approved by the Ethical and Scientific Committees of the University of Kufa, Department of Obstetrics and Gynaecology, and Al-Zahraa Teaching Hospital (Document no. 222, date 09 January 2025). All participants provided their informed consent in writing before enrolment, and confidentiality was ensured by data anonymisation with unique codes and secure restricted access to identifiable information

- **Consent for Publication**

  None.

- **Availability of Data and Material**

  The datasets are available from the corresponding author upon reasonable request.

- **Competing Interests**

  The authors declare that there is no conflict of interest.

- **Funding**

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- **Use of Generative Artificial Intelligence**

  The author declares that ChatGPT, a generative AI-based tool developed by OpenAI, was used solely to enhance clarity and grammatical accuracy during the final editing phase. It was not used for content generation, data analysis, or interpretation.

- **Authors' Contributions**

  All authors contributed to the literature review, study design, data collection, statistical analysis, and manuscript preparation. All authors have read and approved the final version of the manuscript.

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