

Review Article

Triglyceride Glucose Index Is More Robust Surrogate Biomarker for Predicting Type 2 Diabetes Mellitus Than HOMA-IR in Population Attending Aulaqi Specialized Medical Laboratories, Yemen

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Abstract

Insulin resistance (IR) is an independent risk factor for type 2 diabetes mellitus (T2DM). Because only triglyceride levels and fasting blood glucose are required to measure the triglyceride-glucose (TyG) index, and the insulin test, which is used in the homeostatic model assessment of insulin resistance (HOMA-IR) calculation, is costly and unavailable in the majority of laboratories in the cities of developing countries. Thus, the goal of our study was compared the predictive power of HOMA-IR and the TyG index for assessing IR, as well as the incidence and prevalence of T2DM. Methods: From January 2025 to July 2025, a cross-sectional study was carried out at Aulaqi Specialized Med. Lab. Several risk factors were evaluated among 215 participants, 110 of whom had T2DM and 105 of whom without diabetes. The following analysis data were collected; high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), triglycerides (TG), fasting blood glucose (FBG), HbA1c, C-peptide, TyG index and HOMA-IR. The results of the statistical test were considered significant if the P value < 0.05. Results: The T2DM participants had higher mean TyG index (4.87 ± 0.32 vs. 4.66 ± 0.31 , $P < 0.001$) and HOMA-IR (3.07 ± 1.99 vs. 2.32 ± 1.07 , $P = 0.001$) values than non-diabetes. In the receiver operating characteristic (ROC) analysis, the TyG index demonstrated a better performance [area under the curve (AUC) 0.832], with 76.7% sensitivity and 73.8% specificity] in predicting T2DM compared to HOMA-IR (AUC 0.700), which had 67.0% sensitivity and 66.7% specificity ($P < 0.001$). Conclusion: The TyG index correlates with HOMA-IR and outperforms it in terms of T2DM detection and prediction, furthermore, the TyG index regarded as useful and valuable surrogate for estimating IR and for predicting T2DM in individuals who appear to be healthy.

Keywords

HOMA-IR, TyG Index, Type 2 Diabetes Mellitus, Insulin Resistance, Diabetes Prediction

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1. Introduction

Diabetes Mellitus is a prevalent and serious chronic illness globally, resulting in debilitating complications and life-threatening issues. According to the International Diabetes Federation's (IDF) Diabetes Atlas (11th edition), there will be approximately 589 million diabetics worldwide by 2024, with projections suggesting an increase to 853 million by 2050 [1].

In comparison to individuals exhibiting normal glycemic levels, the prevention or delay of diabetes onset can also aid a variety of specific complications, such as microvascular and macrovascular diseases, in addition to psychological disorders such as depression and certain neoplastic conditions, which appear to be more prevalent among those classified as pre-diabetic. Therefore, the early detection of prediabetes and the prompt interference in its advancement are crucial for the prevention of diabetes and its related complications [2-5].

The T2DM is a long-term condition characterized by both defective insulin secretion and IR. For assessing IR, the hyperinsulinemic-euglycaemic clamp is regarded as the gold standard; however, its costly high and impracticality have led to the creation of alternative methods for estimating insulin sensitivity [6]. In recent years, numerous mathematical models have been emerged to facilitate the assessment of IR, with the HOMA-IR being a validated procedure for evaluating IR using fasting serum insulin and serum glucose levels [7]. Blood insulin levels must be estimated in order to compute HOMA IR, which is not typically performed in healthcare settings [8].

Recently, an examination utilizing the triglyceride–glucose (TyG) index has been established. This method demonstrates a considerable sensitivity in evaluating IR. Fasting blood glucose and triglyceride levels are the only requirements for the measurement with TyG index. Because of this, the TyG index can be used as a testing tool for evaluating IR in medical facilities across developing countries [9]. The TyG index is a more recent alternative surrogate IR marker. In addition to being validated as an indicator of insulin resistance, the TyG index has been shown to predict T2DM, metabolic syndrome (MS), non-alcoholic fatty liver disease, and cardiovascular disorders [10].

In this study, we assessed the ability of the HOMA-IR and TyG index to predict the incidence of T2DM and whether the index is better at predicting both the incidence and prevalence of T2DM disease. Furthermore, we established the best cutoff points for each index in relation to T2DM prediction, along with the corresponding area under the curve (AUC), sensitivity, and specificity values.

2. Materials and Methods

This cross-sectional research examined clinical data from Yemeni subjects who visited Aulaqi Specialized Medical Laboratories between January 2025 and July 2025. This study included 215 Adults (105 normal subjects with mean age of 34.42 ± 10.62 and 110 unrelated T2DM patients with mean

age of 41.20 ± 12.48). The criteria for inclusion included having complete data measurements, fasting blood glucose of T2DM patients not more than 150 mg/dl and the age of participants not more than 45 years. Medical history, and laboratory evaluations including serum total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, fasting blood glucose, and serum C-peptide were collected from each participant. Exclusion criteria included incomplete medical record information.

The formula for calculating the TyG index was $(\ln [\text{fasting triglycerides (mg/dL)} \times \text{FPG (mg/dL)}] / 2)$ [11]. The University of Oxford's Diabetes Trials Unit's HOMA-IR online calculator was used to calculate the homeostasis model assessment of insulin resistance (HOMA-IR). You can use this calculator at <https://www.dtu.ox.ac.uk/homacalculator/>.

The main outcome of this study was to assess the potential of the TyG index as a more robust surrogate biomarker for the prediction of T2DM in comparison to HOMA-IR. The Key performance indicators for this predictive analysis included the area under the curve - the receiver operating characteristic (AUC-ROC), alongside sensitivity and specificity indices.

Statistical Analysis

A statistical analysis was conducted utilizing the Statistical Package for the Social Sciences (SPSS) version 30.0 (IBM Co., Armonk, NY, USA) to ascertain statistical significance among groups, and to elucidate continuous variables such as age, anthropometric measurements, HOMA-IR and TyG index variables, whereby means and standard deviations were computed. Through ROC curve analysis, the diagnostic efficacy and comparative analysis of the HOMA-IR and TyG index in predicting T2DM were assessed; SPSS was used to determine the AUC, sensitivity, and specificity. Statistical significance was defined as a P -value < 0.05 .

Excellent (AUC 0.90-1.00), good (AUC 0.80-0.89), fair (AUC 0.70-0.79), poor (AUC 0.60-0.69), or failure/no discriminatory capacity (AUC 0.50-0.59) were the interpretations of the AUC-ROC values [12].

3. Results

The comparative analysis of the clinical characteristics and biochemical parameters among the study participants, categorized according to whether T2DM is present or not, are illustrated in Table 1. Among 215 participants, 105 (48.8%) had non-T2DM, and 110 (51.2%) had T2DM. The average age of participants without T2DM was 34.42 ± 10.62 years, in contrast to 41.20 ± 12.48 years for those with T2DM. Notably, the TyG index ($P < 0.001$), HOMA-IR ($P = 0.001$), HbA1c ($P < 0.001$) and fasting blood glucose levels ($P < 0.001$) were significantly elevated in individuals with T2DM compared to their non-T2DM participants. Although C-peptide results were observed to be lower in non-T2DM individuals relative

to those with T2DM, but this difference was not statistically significant.

Table 1. Clinical Characteristics and Biochemical Parameters Among the Study Participants.

Variable	Non T2 DM (n=105)	T2DM (n=110)	P-value
n (male/female)	105 (63/42)	110 (75/35)	NA
Age (Years)	34.42 ± 10.62	41.20 ± 12.48	<0.001*
Fasting blood glucose (mg/dl)	90.83 ± 6.88	130.34 ± 47.19	<0.001*
Total Cholesterol (mg/dl)	183.35 ± 35.43	188.18 ± 39.15	0.354
Triglyceride (mg/dl)	148.88 ± 107.82	157.68 ± 96.42	0.528
HDL-C (mg/dl)	40.62 ± 8.97	42.56 ± 9.20	0.133
LDL-C (mg/dl)	115.38 ± 27.41	122.36 ± 33.21	0.106
C-peptide	3.12 ± 1.32	3.46 ± 1.43	0.077
HbA1c (%)	4.79 ± 0.24	6.43 ± 1.54	<0.001*
HOMA-IR	2.32 ± 1.07	3.07 ± 1.99	0.001*
TyG index	4.66 ± 0.31	4.87 ± 0.32	<0.001*

Compressions were performed by independent Samples t-test; data were presented as mean ±SD; *P<0.05 is statistically significant; n: number of individuals; TyG: Triglyceride Glucose Index; HOMA-IR: Homeostatic model assessment of insulin resistance.

Table 2. The Sensitivity, Specificity, Optimal Cut-Off Values, and AUC-ROC for T2DM Prediction.

	AUC (95% CI)	AUC Std. Error	Sensitivity%	Specificity%	Cut-off	P-value
TyG index	0.832 (0.776-0.889)	0.029	76.7	73.8	4.70	<0.001*
HOMA-IR	0.700 (0.625-0.775)	0.038	67.0	66.7	2.40	<0.001*

TyG: triglyceride-glucose; HOMA-IR: homeostasis model assessment-insulin resistance; AUC: area under the curve; AUC Std. Error: Area under the curve standard error; *P-value<0.05 is statistically significant.

Table 3. HOMA-IR and TyG Index of Individuals Without Diabetes on a ROC Curve.

TyG Index	HOMA-IR		Total	OR (95% CI)	P-value
	IR	non-IR			
≥ 4.7	22	21	43	2.6 (1.138-5.764)	0.02*
< 4.7	18	44	62		
Total	40	65	105		

TyG: Triglyceride Glucose Index; HOMA-IR: Homeostatic model assessment of insulin resistance; OR: Odds Ratio; CI: Confidence Interval; *P-value<0.05 is statistically significant.

The HOMA-IR and TyG index ROC curve for predicting T2DM in the study population shows in Figure 1. Table 2 summarizes the diagnostic competence of several parameters

for T2DM prediction. The AUC for the TyG index was calculated to be 0.832 (95% CI 0.776-0.889, $P<0.001$), which is significantly higher than HOMA-IR, recorded at 0.700 (95%

CI 0.625-0.775, $P < 0.001$). In the comparative analysis of ROC curves, TyG index demonstrated superior effectiveness compared to HOMA-IR in the identification of T2DM onset. Table 2 also presents the optimal cut-off values, sensitivity, and specificity for each parameter. The sensitivity of the TyG index was found to be 76.9%, with a specificity of 73.8%. In comparison, HOMA-IR revealed a sensitivity of 67.0% and a

specificity of 66.7%. Our findings indicate that the TyG-Index has greater accuracy and reliability than the HOMA-IR for predicting and diagnosing T2DM.

The TyG index and HOMA-IR showed a significant concordance ($P = 0.02$), as Table 3 demonstrates. According to OR values, participants with a TyG index of ≥ 4.70 were three times more risk of IR than those with a TyG index of < 4.70 .

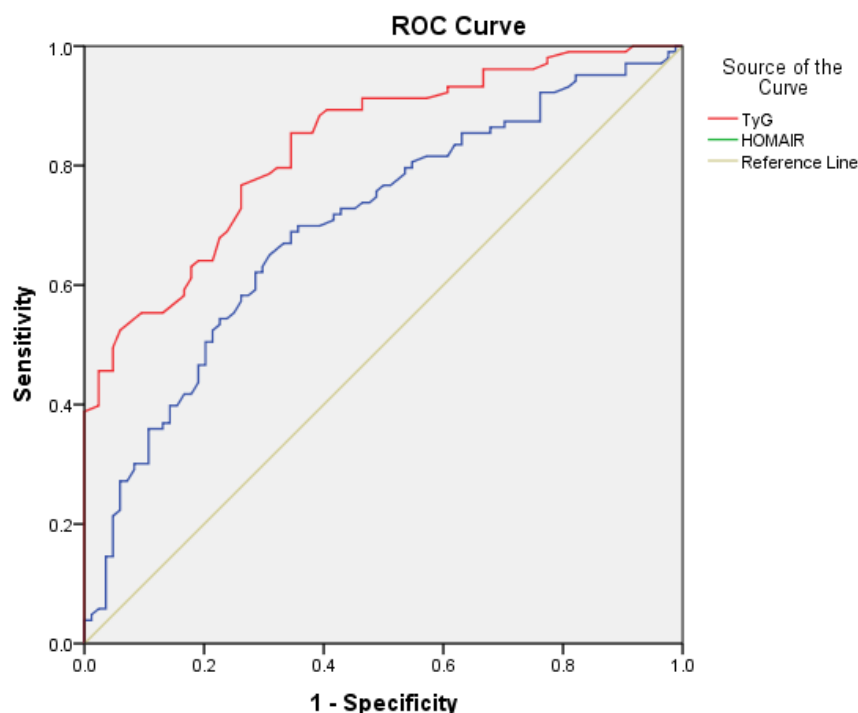


Figure 1. TyG Index and HOMA-IR ROC (Receiver Operating Characteristic) Curves for T2DM Prediction in the Study Participants.

4. Discussion

In this study, we evaluated the predictive power of the TyG index to determine which Yemeni participants are most likely to develop type 2 diabetes in its early stages. It showed that risk variables like insulin resistance were positively associated with T2DM. According to our findings, the TyG index demonstrates superior diagnostic accuracy compared to HOMA-IR and shows as a highly efficient tool for predicting the occurrence of T2DM.

The assessment of IR represents a critical objective that increasingly important in clinical and epidemiological research, given its possible involvement in the pathogenesis of metabolic syndrome and associated development risk of T2DM or cardiovascular disease (CVD) [13-15]. Additionally, IR has a significant impact on metabolic syndrome, T2DM and CVD [23]. Thus, it's critical to identify IR early in those who may eventually develop T2DM or CVD in the future. The TyG index is one of the detection methods that has been proposed as a trustworthy predictor of T2DM [16-18].

In countries characterized by economic challenges within their healthcare systems, the routine plasma insulin measurements for HOMA-IR index calculation are often not readily available, necessitating the utilization of alternative indices based on the role of glucolipotoxicity as a crucial factor in the development of IR [18]. Given that hypertriglyceridemia interferes with glucose metabolism within the muscle, which is the primary organ for insulin action and glucose uptake, the TyG index appears to predominantly reflect muscle insulin resistance, whereas the HOMA-IR index primarily indicates hepatic insulin resistance [19].

Compared to other indicators that use insulin in clinical and epidemiological investigations, the TyG index is more accessible and cost-effective because it does not require fasting insulin level analysis. Moreover, primary health care laboratories routinely screen for triglycerides and glucose [20]. In other words, the ease and affordability of TyG index calculation render it the best choice for extensive clinical application, especially in basic care facilities [21, 22].

Insulin resistance is indicated by the TyG Index, but through a distinct metabolic pathway when contrasted with HOMA-IR. Elevated triglycerides increase the free fatty acids

levels, resulting in a higher transfer of free fatty acids from adipose tissue to other tissues, which contributes to IR. Hypertriglyceridemia increases the amount of free fatty acids that are transported to the hepatic tissue, which raises the amount of glucose produced by the liver. Elevated levels of triglycerides in the muscles and liver can affect the metabolism of glucose in each organ [23]. In subjects with IR, the normal production of insulin is insufficient to effectively facilitate the glucose transfer from the bloodstream to peripheral tissues, such as fat tissues and muscle, resulting in elevated levels of blood glucose. To keep levels of blood glucose within a normal range, an increased insulin production is required due to insulin resistance [24-26].

The prospective studies showed that insulin resistance is a major cause of diabetes and occurs several years prior to the onset of diabetes [27]. The TyG-Index is a better index for determination of IR than other indices like the HOMA-IR, according to previous investigations [28]. In South Korea, China and other countries, the relationship between the TyG index, IR, and the T2DM incident has also been investigated [29-33].

The TyG index was found to be significantly correlated with both the prediction of diabetes risk and insulin resistance in the current study. The TyG index in particular was found to be a significant predictor of T2DM risk in studies on non-diabetic populations in Singapore, Thailand, and South Korea [30, 34, 35]. These findings support our findings. An elevated TyG index is independently linked to a greater risk of developing incident T2DM, according to data from another Chinese cohort [36]. According to other studies, the TyG index was validated for use as insulin resistance screening tool in a number of populations worldwide [37, 38].

In our study, the HOMA-IR had an AUC-ROC of 0.700, while the TyG index had a significantly higher AUC-ROC of 0.832. This finding aligns with previous research demonstrating the TyG index superior diagnostic ability to identify IR [11].

The TyG index, in current study, had a larger AUC-ROC, which indicates that it had higher sensitivity (76.7%) and specificity (73.8%) than HOMA-IR, which had 67.0% sensitivity and 66.7% specificity. These findings imply that the TyG index is more accurate and practical tool for early detection in clinical settings, as it both predicts T2DM and is more sensitive. In line with our finding, the studies carried out by Guererro-Romero et al (2010) and Park MS (2024) demonstrates that compared to HOMA-IR, the TyG index has higher sensitivity and specificity [11, 39]. Furthermore, other studies revealed that the TyG index is a superior predicting tool of T2DM than HOMA-IR [10, 28, 40]. A cross-sectional study of 82 patients in Brazil (2011) found that the TyG index performed better than HOMA-IR in predicting diabetes [28, 40]. A study by Khan and colleagues, in 2018 revealed that the TyG index AUC of 0.764 (95% CI 0.700-0.828, *P*-value 0.001) was superior to the HOMA-IR, which was 0.619 (95% CI 0.545-0.694, *P*-value 0.001) on individuals with and without

metabolic syndrome [41]. Another study used the ROC method to report the TyG index diagnostic value at a specific optimal cut-off point, and then compared it with HOMA-IR. The TyG index has a cut-off of 4.65, which is superior to HOMA-IR in terms of sensitivity (84%) and specificity (45%) [42].

The TyG index in the current study has a higher specificity (the percentage of subjects without IR or T2DM) than HOMA-IR, making it useful for screening purposes. According to this study, Individuals with a TyG index of more than 4.70 may have IR and be at risk of T2DM. The odds ratio (OR) value suggested that individuals who had a TyG index of ≥ 4.70 were three times more likely than those who had a TyG index of < 4.70 to experience IR.

5. Conclusion

A popular choice for extensive clinical use, especially in primary care settings, is the TyG index due to its affordability and ease of calculation. Unlike HOMA-IR, which requires fasting insulin measurements, the TyG index calculation only requires fasting blood glucose and triglyceride levels, which are routinely tested in conventional clinical practice. Furthermore, the TyG index is easily incorporated into current clinical workflows because patients at risk for diabetes constantly have their triglycerides and glucose levels checked. Because of its high sensitivity and specificity, the TyG index may be used for early detection of metabolic syndrome and enable prompt interventions to stop the development of more serious metabolic diseases like T2DM. Compared to HOMA-IR, the TyG index is more predictive of T2DM incidents. In order to assess IR and predict T2DM, it may be more beneficial to use the TyG index rather than HOMA-IR.

Abbreviations

TyG	Triglyceride-Glucose Index
T2DM	Type 2 Diabetes Mellitus
IR	Insulin Resistance
HOMA-IR	Homeostatic Model Assessment of Insulin Resistance
FBG	Fasting Blood Glucose
TC	Total Cholesterol
ROC	Receiver Operating Characteristic Analysis
AUC	Area Under the Curve

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Author Contributions

Mohammed Ahmed Hajar: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation,

Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Sami Sultan Ahmed: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – review & editing

Basem Mohammed Abdulfattah: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Validation, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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