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RESEARCH ARTICLE

Utility of the Tyg Index in Detecting IR Among Normal-Weight Individuals: A Cross-Sectional Study from South India

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Abstract: TyG index are use as surrogate of the clinical and epidemiological settings for access Insulin resistance (IR). The study mainly aims to emphasise utility of TyG index as a surrogate marker for detecting IR among the normal-weight individuals. Cross-sectional research employed in this study for collection data. The study adopts a purposive sampling strategy to enrol participants aged 21 to 50 years with normal BMI. A total of 58 participants were enlisted based on sample size calculations. The finding of the study indicates that the results of the HOMA-IR test show a positive relationship with fasting glucose ($r = 0.624$, $p < 0.0001$), fasting insulin (r = not supplied but inferred extremely high), triglycerides ($r = 0.347$, $p = 0.0076$) and TyG index ($r = 0.454$, $p = 0.0003$). When it predicts IR, the TyG Index has a sensitivity of 74.36%, NPV of 56.52%, PPV of 82.86% and specificity of 68.42%.

Keyword: TyG index, IR, HOMAIR, BMI, triglyceride, glucose, health.

INTRODUCTION

Insulin resistance (IR) is a metabolic abnormality precedes mellitus of type 2 diabetes, metabolic syndrome and cardiovascular disease. IR assessment gold standard, the hyperinsulinemic-euglycemic clamp, and surrogate models like "Homeostatic Model Assessment of IR" (HOMA-IR), are reliable but need insulin assays, which limit widespread use during routine practice. "Triglyceride-Glucose" (TyG) index has emerged as a low-cost, simple marker based on "triglyceride and fasting glucose levels", both of which are commonly considered in clinical settings. The TyG index is a reliable and valid index for IR assessment; it is also associated with "hyperinsulinemic-euglycemic clamp". Through integrating glucose levels and fasting triglyceride, TyG index offers easy-to-calculate surrogate for the insulin sensitivity, enabling identification of individuals at risk, including those who have "metabolically obese normal-weight" (MONW) phenotypes.

***Aim*:**
The study aims to analyse the utility of the TyG index as a surrogate marker for detecting IR among normal-weight individuals, using HOMA-IR as a reference standard in South India.

***Objective*:**

- To explore proportion of normal-BMI individuals classified in IR by the TyG index.
- To contrast the TyG index diagnostic performance against HOMA-IR in detecting IR.
- To emphasise the sensitivity, specificity, "positive predictive value" (PPV) and "negative predictive value" (NPV) of the TyG index.
- To assess the correlation between the TyG index and metabolic parameters like fasting glucose, HDL cholesterol and triglycerides.

LITERATURE REVIEW

TyG index can use as surrogate in epidemiological and clinical settings for assessing IR. An early and innovative indication of IR is TyG Index[1]. This index is mainly functions as proxy for β-cell function and insulin sensitivity by merging triglyceride levels and fasting blood glucose. In some demographic groups, TyG index poses as a strong predictor for pre-DM risk, that emphasise customised risk assessment significance and its intervention methods. Routine tests in laboratory are a good first-line screening tool for pre-DM as they are easy to acquire parameters in settings with the limited resources. For doctors to quickly identify and intervene with high-risk individuals, this development may be essential.

TyG index is a cost-effective way of assessing IR because glucose concentrations and plasma triglyceride are measured at the time of health check-ups[2]. In the heterogeneity dynamics of predictive value of TyG-related parameters and obesity indices among different populations, further research is warranted on the associations of these measures with T2DM risk[3]. TyG index is a logarithmic expression, as a low-cost marker that can allow for assessing IR[4]. Consequently, TyG's significance in IR discrimination is noteworthy, which is explained by the fact that glucolipotoxicity is one of the primary mechanisms of IR modulation. Because hypertriglyceridemia is a reason and effect of aberrant G metabolism, TG affects the findings independent of G. Decreased muscle G uptake and reduced hepatic glycogen production can result from the insulin binding receptor blocking insulin action when ectopic lipid builds up in the liver and skeletal muscle. To put it another way, elevated fatty acid oxidation restricts the amount of G that insulin can use.

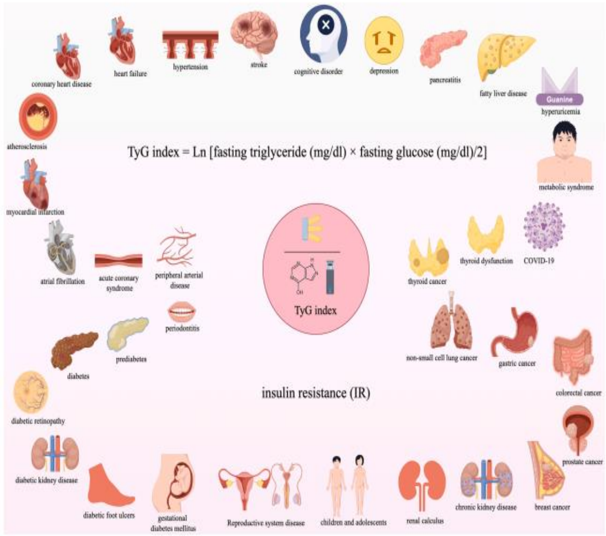


Figure 1: TyG index association with several diseases[5]

The results of[5] , investigations suggest that the TyG index can also serve as an important and useful biomarker for a different type of illnesses. Consequently, the insights obtained from the TyG index can be used to tailor disease risk management strategies[9]. Furthermore, several studies have shown that therapeutic effects in disease intervention can be obtained via therapy modalities that are informed by the TyG index. The TyG index is regulated through interventions like dietary fibre curcumin, supplementation, igagliprazin, dagagliprazin and cranberry nutraceutical extract. However, it is crucial to recognise that this field of study is still in its infancy and which use TyG index as a foundation for illness treatment cans positive results. Additionally, tracking changes in the TyG index throughout the course of disease management may provide insightful advice for treatment strategies.

Of these, the TyG index, calculated through integrate triglycerides and fasting glucose, is generally a helpful indicator for adult IR. Furthermore, altered TyG indices that incorporate obesity indices like BMI, "waist circumference", and "waist-to-height ratio" (WHtR) may serve as substitute indicators for determining IR[6]. Lee and associates found that among Americans, the TyG index in conjunction with BMI or WC was better than the TyG index alone. Since fasting develop a steady basal state where glucose plasma and insulin levels should be kept within normal ranges in a healthy person, IR indexes shows hepatic IR/sensitivity and the basal insulin secretion through utilising pancreatic β cells. Nevertheless, these indices also drawbacks including no universal cut-off values, insensitivity, non-standardisation and variations in β-cell function with time for infrared.

For IR identification and associated conditions, like type 2 diabetes mellitus, MASLD, multiple sclerosis and cardiovascular illnesses, HOMA-IR is often utilised. Similarly, the TyG index is a better marker than HOMA-IR for diagnosis of IR-related disorders[7]. Type 2 diabetes, future cardiovascular mortality, myocardial infarction and stroke are all substantially correlated with the index of TyG, indicating that IR major influences the aetiology of cardiovascular and metabolic disorders[8]. Due to it is simple dynamic that allow them to compute and measure by using a commonly available measurements of laboratory, this index is suitable for daily clinical practice. Therefore, TyG index can also allow to aid in early detection of individuals who are at high risk of cardiovascular or type 2 diabetes events.

METHODOLOGY

- This is a cross-sectional study conducted in the Department of General Medicine, Sree Balaji Medical College and Hospital, Chennai, over 18 months.
- Sample Size formula for pooled variation:

$$S_p = \sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{(n_1+n_2-2)}}$$

SP = 18.5
$N=2\{ z\sigma^2 E^2 \}$
N = 56
Z 2 1 -α/2 = 95% level of confidence
E^2= error margin, i.e., 5%
σ = is calculated by pooling the SD, i.e., calculated using the SP formulae, i.e., 18.5

- The study involved purposive sampling and chose 58 participants, aged between 18 and 50 years, with a normal BMI: 18.5–24.9 kg/m².
- Individuals with known hypertension, diabetes, dyslipidemia, on medications or chronic systemic illnesses affecting lipid or glucose metabolism are excluded.
- After acquiring informed consent, demographic data, clinical examination and medical history are recorded.

- Anthropometric measurements like BMI, height and weight. Venous blood samples are collected after overnight fasting for biochemical analysis.
- Tests involve fasting plasma glucose, triglycerides, fasting insulin, LDL cholesterol and HDL cholesterol.
- IR was calculated using the HOMA-IR, which served as the reference standard.
- The TyG index was derived using the formula:

TyG index = ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL) / 2]

- Normal: <8
- IR Indicator: >8.7 (higher values indicate higher risk of metabolic syndrome and IR)

Inclusion and Exclusion Criteria
Inclusion Criteria:
1. Ages: 18-50 Years
2. Normal-weight individuals defined by BMI

Exclusion Criteria:
1. Age: more than 50 years
2. During the trial, a history of hyperglycemia or fasting blood sugar levels of 126 or above, if known.
3. History of hypertension and dyslipidemia
4. History of chronic kidney, liver, heart, cancer, thyroid, or tuberculosis while on medicine
5. Stimulants, antipsychotics, statins, and diuretics users.
6. Not willing to participate

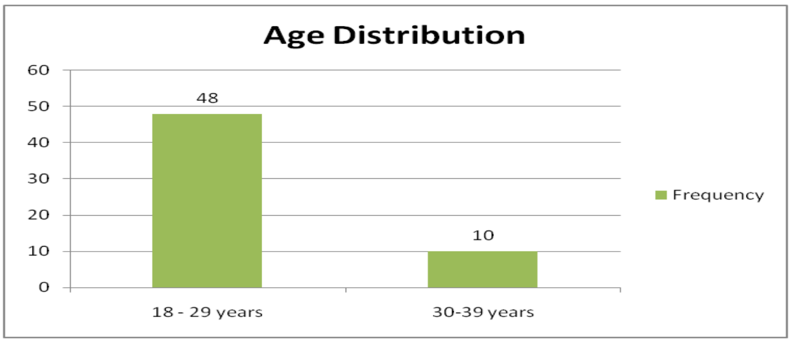
Study Procedure
Participants are categorised into insulin-resistant and non-insulin-resistant groups based on HOMA-IR cut-offs. TyG index diagnostic accuracy was assessed by calculating sensitivity, specificity, PPV, and NPV. Correlation analysis among HOMA-IR and TyG index, fasting glucose, lipid profile and triglycerides parameters is also performed. Statistical analysis is carried out by using descriptive statistics to explore the characteristics of the baseline. T-test and Chi-square test applied for group comparisons, while Pearson's correlation coefficient allows for assessing relationships between metabolic and TyG variables. A p-value < 0.05 is considered statistically significant.

RESULT

Age Distribution
Participants of the study are split up among different age groups. 10 individuals (17.3%) are between the ages of 10 and 39, while 48 participants (82.7%) are between the ages of 18 and 29.

TABLE 1: Age Distribution of Participants

Age Distribution		
Age	**Frequency**	**Percent**
18 - 29 years	48	82.7
30-39 years	10	17.3



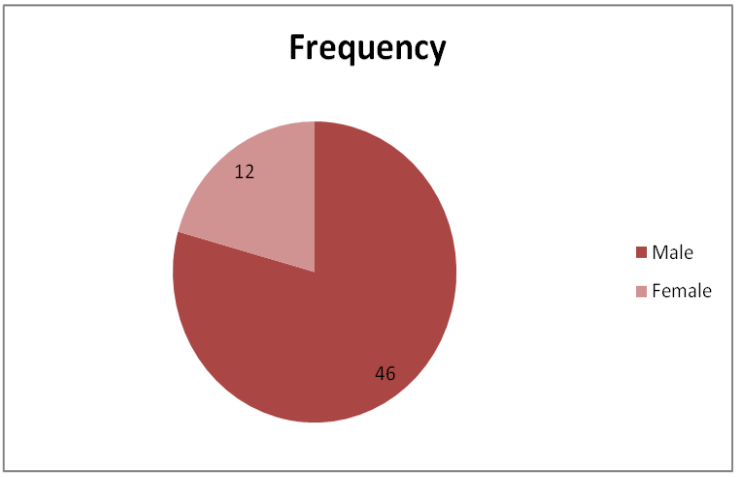
Graph 1: Age Distribution of Participants

Gender Distribution

Male participants outnumbered female participants in the study. There are 12 participants (20.6%) who are female and 46 participants (79.4%) who were male.

TABLE 2: Gender Distribution of Participants

Gender Distribution		
Gender	**Frequency**	**Percent**
Male	46	79.4
Female	12	20.6
Total	58	100



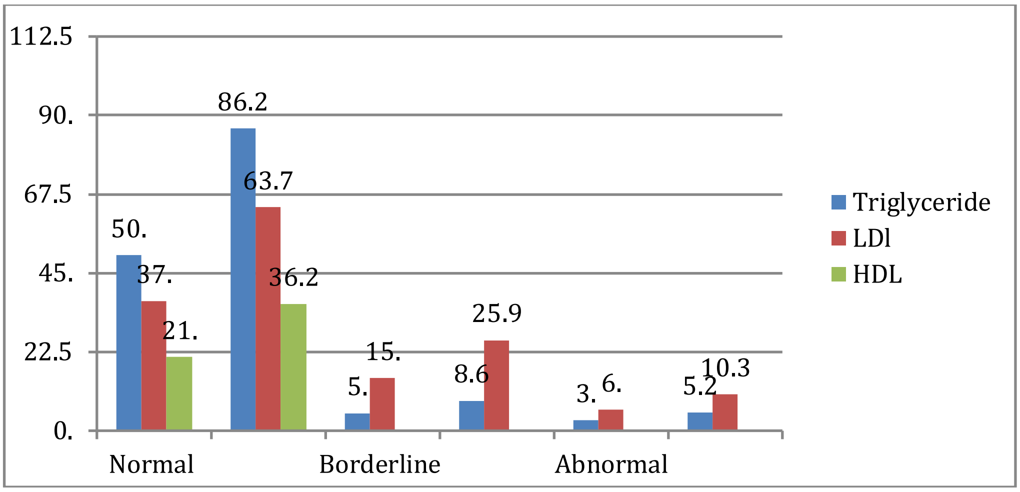
Graph 2: Gender Distribution of Participants

Lipid Profile – Triglyceride Levels

Among participants, 50 of the individuals which are 86.2% has normal triglyceride levels, 5 individuals (8.62%) has borderline levels, and 3 individuals (5.17%) having an abnormal levels. Among total of 37 participants (63.7%) has normal 15 participants (25.86%) has borderline and 6 participants with 10.34% has abnormal LDL levels. Among these participants, 21 individuals stand with 36.2% has normal HDL levels, while 37 of the individuals which are 63.7% have abnormal HDL levels.

Table 3: Lipid Profile Levels of Participants

Lipid Profile	Normal		Borderline		Abnormal	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percen t**
Triglyceride	50	86.2	5	8.62	3	5.17
LDl	37	63.7	15	25.86	6	10.34
HDL	21	36.2			37	63.7



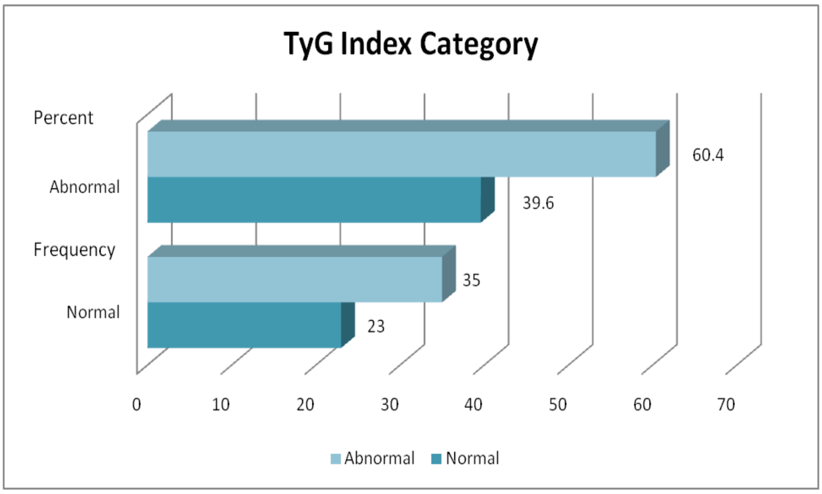
Graph 3: Lipid Profile Levels of Participants

TyG Index Category

In this study, 35 participants (60.4%) have abnormal TyG index levels, while 23 participants (39.6%) have normal levels.

TABLE 4: TyG Index Category among Participants

TyG Index Category		
TyG Index	Frequency	Percent
Normal	23	39.6
Abnormal	35	60.4
Total	58	100



GRAPH 4: TyG Index Category among Participants

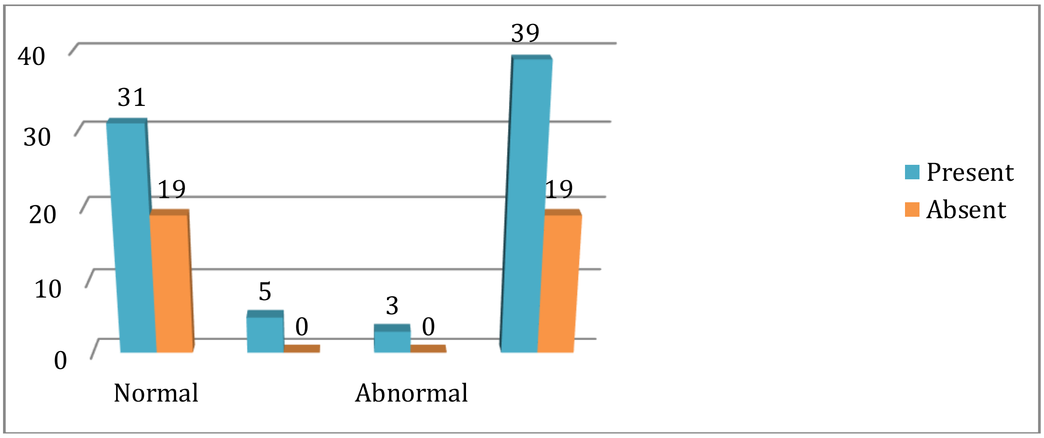
Association between Triglycerides and IR

All participants has abnormal triglyceride levels has IR of 100.0%, while 62% of those has normal levels of IR. There is also no statistically significant correlation, since p-value is 0.104.

Table 5: Association between Triglycerides and IR

Association Between Triglycerides and IR ASSOCIATION

Triglycerides	IR		Total	chi-square value	p-value
	Present	Absent		4.521	0.104
Normal	31	19	50		
	62.00%	38.00%	100.00%		
Borderline	5	0	5		
	100.00%	0.00%	100.00%		
Abnormal	3	0	3		
	100.00%	0.00%	100.00%		
Total	39	19	58		
	67.24%	32.76%	100.00%		



Graph 5: Association between Triglycerides and IR

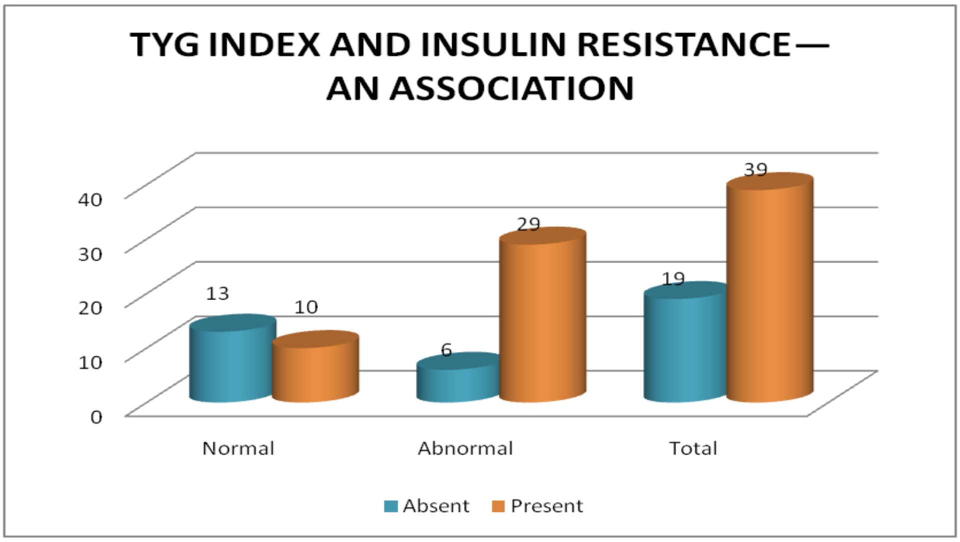
Association between TyG Index and IR

There is a statistically significant correlation between IR and the TyG Index ($\chi^2 = 9.771$, $p = 0.0018$). 82.85% of people with an abnormal TyG index have IR. Conversely, IR is present in just 43.47% of those with a normal TyG index. This implies that IR may be a valuable surrogate diagnostic because it is strongly correlated with an abnormal TyG index.

TABLE 6: TyG Index and IR—an Association

TYG INDEX AND IR—AN ASSOCIATION ASSOCIATION					
TyG Index	IR		Total	chi-square value	p-value
	Absent	Present		9.771	0.0018
Normal	13	10	13		
	56.20%	43.70%	100.00 %		
Abnormal	6	29	35		
	17.14%	82.85%	100.00 %		

Total	19	39	58		
	32.75%	67.24%	100.00 %		



Graph 6: TyG Index and IR—an Association

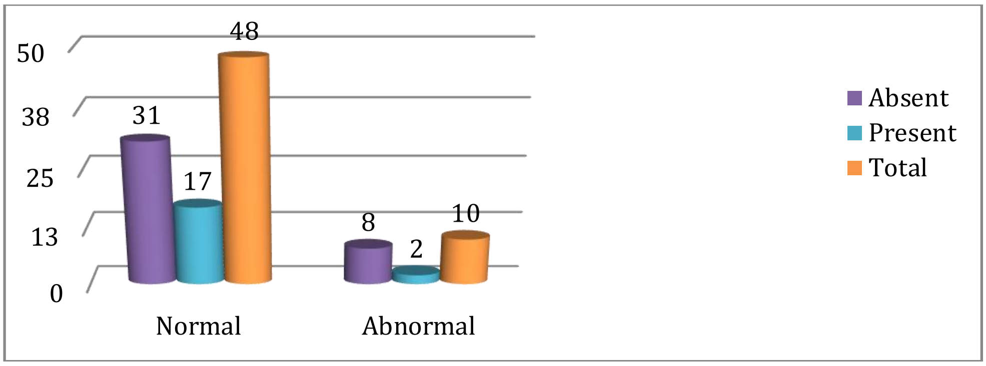
Association between HDL Levels and IR

This study emphasises that 48 participants (82.7%) has normal and 10 participants with 17.3% has abnormal HDL levels. Among normal HDL levels, 31 (64.58%) are not have IR, while 17 (35.41%) are have. In contrast, among abnormal HDL levels, 8 (80%) not have IR, whereas 2 (20%) among them are have. There are no statistically significant difference among these two groups are found as per the chi-square test, with value p = 0.3447.

Table 7: Association between HDL Levels and IR

Association Between HDL Levels and IR ASSOCIATION					
TyG Index	**IR**		**Total**	**chi-square value**	**p-value**
	Absent	**Present**		0.893	0.3447
Normal	31	17	48		
	64.58%	35.41%	100.00%		
Abnormal	8	2	10		
	80.00%	20.00%	100.00%		
Total	39	19	58		
	67.24%	32.76%	100.00%		

Graph 7: Association between HDL Levels and IR



Correlation between HOMA-IR and Other Variables

The study looked at anthropometric and metabolic characteristics that are correlated with HOMA-IR.

1. There is a positively correlated between HOMA -IR and triglycerides (mg/dL) (r = 0.34, p = 0.0076).
2. HOMA-IR indicates a positive connection with TyG index (TyG index) (r = 0.45, p = 0.0003).
3. There is a negative correlation HOMA-IR and between HDL (mg/dL) (r = -0.3549, p = 0.0063).
4. It is not statistically significant, although there is a positive connection between LDL and HOMA-IR (mg/dL) (r = 0.0742, p = 0.5797).
5. The HOMA-IR has significant positive connection with fasting glucose (mg/dL) (r = 0.6239, p < 0.0001).
6. There is a negative connection between HOMA-IR and BMI (r = 0.2529, p = 0.0555).
7. There is not statistically significant, although a modest positive connection among HOMA-IR and age (r = 0.155612, p = 0.2434).

Table 8: Correlation between HOMA-IR and Other Variables

Variable	**HOMAIR**		
	Pearson Correlation	**P-Value**	**N**
HOMAIR	1		58
Triglycerides (mg/dL)	0.34701		58
TyG index	0.45379	0.0003	58
HDL (mg/dL)	-0.3549	0.0063	58
LDL (mg/dL)	0.0742	0.5797	58
Fasting glucose (mg/dL)	0.623989	<0.0001	58
BMI	0.252936	0.0555	58
Age	0.155612	0.2432	58

TyG Index as a Surrogate Marker for IR

Our standard for determining how effectively the TG-G index predicted IR as a surrogate measure is the HOMA-IR. Of the 58 individuals who underwent testing, 39 (67.2%) are found to be insulin resistant based on the HOMA-IR test, however, 35 (60.3%) are found to be insulin resistant based on the TyG index.

TABLE 9: TyG Index as a Surrogate Marker for IR

TyG Index		**HOMA – IR**		
		Positive	Negative	Total
	Positive	29	6	35
	Negative	10	13	23

	Total	39	19	58

Our results indicate that the TyG index's sensitivity of 74.36% demonstrated its ability to correctly identify a sizable portion of people with IR. With a specificity of 68.42%, the ability to accurately classify non-IR persons was deemed to be moderate. The high positive predictive value (PPV) of 82.86% indicates that people with TyG are highly likely to actually have IR. But when the TyG index is negative, the negative predictive value (NPV) was somewhat lower at 56.52%, suggesting a moderate chance of actually being IR-negative.

TABLE 10: TyG Index in Comparison to HOMA – IR in Predicting IR

Sensitivity	74.35897
Specificity	68.42105
Positive Predictive Value	82.85714
Negative Predictive Value	56.52174

DISCUSSION

This study sought to evaluate the prevalence of IR in people with a normal BMI to ascertain the usefulness of the TyG Index as a surrogate measure. IR has found in 67.24% of people with normal weight, supporting the idea that BMI is not a reliable measure of metabolic health on its own. Despite statistically insignificant results, triglyceride levels showed a distinct pattern, with 100% of subjects in the borderline or abnormal triglyceride category having IR. The TyG Index showed a strong connection ($p = 0.0018$). 82.85% of individuals with a higher TyG score had IR.

The correlation study's findings showed that HOMA-IR was positively correlated with:

- Fasting glucose ($r = 0.624$, $p < 0.0001$)
- TyG index ($r = 0.454$, $p = 0.0003$)
- Triglycerides ($r = 0.347$, $p = 0.0076$)

On the other hand, there was a negative correlation between HDL and HOMA-IR ($r = -0.355$, $p = 0.0063$). The lack of substantial associations between LDL, BMI, and age further supports the idea that normal-weight people's IR may not be accurately reflected by traditional anthropometric or lipid markers.

With its sensitivity of 74.35%, specificity of 68.42%, positive predictive value of 82.85%, and negative predictive value of 56.52%, the TvG index appears to be a clinically straightforward, widely available, and reasonably priced method of evaluating IR. The TyG index costs about Rs. 220 compared to Rs. 2250 for the HOMA-IR. There is a ten-fold cost-saving investigation available in every town across our nation. When combined, these results support the inclusion of metabolic markers in regular screening, even for those who seem healthy by BMI criteria. These markers include the TyG index, fasting glucose, fasting insulin, and triglyceride levels. For the early detection of IR, the TyG index proves to be a viable and trustworthy substitute for insulin-based techniques due to its affordability and ease of use, particularly in settings with limited resources.

Other possible surrogate measures to take into account are triglycerides, either alone or in combination with HDL cholesterol. When an individual had prediabetes and a high triglyceride level (150 g/dL and above), they were at risk for developing IR. White people are more likely to have IR when their triglyceride to HDL ratio is high. Patients have a ratio which is high than 3.0 are also likely to have IR. Female ratios with 2.5 or higher and male ratios of 3.5 or greater are IR indicative. Under a well-established diagnostic performance than HOMA-IR, index of TyG is act as a promising marker for predicting BMI presence. This tool is useful for risk identification due to specificity, simplicity and high sensitivity. Type 2 diabetes and cardiovascular disease are at-risk populations can lessened if TyG index is incorporated in the standard clinical practice for foster early identification, focuses on management of the metabolic disorders and risk assessment.

CONCLUSION

TyG index indicates that metabolic disorders can happen regardless of body weight category, and IR is strongly linked to elevated triglyceride levels, fasting glucose and insulin. These findings of the study underscore that importance of comprehensive metabolic screening is remain beyond BMI in for analysis individuals at risk. TyG index are an acceptable HOMA-IR indicator which help in detect IR. It is crucial for explore to IR in normal-weight individuals early as it left untreated, it can become the reason of type 2 diabetes, metabolic problems and cardiovascular disease. For enhance early management and identification, clinical evaluations have to incorporate routine with the metabolic assessments, like insulin sensitivity markers, fasting glucose, lipid profiles, and insulin levels. TyG's in IR discrimination is explained by the fact that glucolipotoxicity is acted as a primary mechanism for modulation of IR. Similarly, TyG index is a better marker than HOMA-IR for diagnosis of IR-related disorders.

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