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COMBINED TRIGLYCERIDE–GLUCOSE INDEX AND WAIST-TO-HEIGHT RATIO AS PREDICTORS OF SILENT CARDIOMETABOLIC RISK IN APPARENTLY HEALTHY ADULTS: A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Cardiometabolic diseases often develop silently before progressing to overt cardiovascular disease and type 2 diabetes mellitus. Early identification of individuals at increased risk is essential for timely preventive interventions. The Triglyceride–Glucose (TyG) Index, a surrogate marker of insulin resistance, and the Waist-to-Height Ratio (WHtR), an indicator of central obesity, have individually shown promise in predicting cardiometabolic risk. However, evidence regarding their combined utility in apparently healthy adults is limited. **Objective:** To evaluate the combined Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) as predictors of silent cardiometabolic risk in apparently healthy adults. **Materials and Methods:** A retrospective observational study was conducted at Central Hospital, Garden Reach, South Eastern Railway, Kolkata, India. Medical records of 100 apparently healthy adults aged 18–65 years who underwent routine health check-ups between June 2022 and June 2025 were reviewed. Demographic, anthropometric, and biochemical data were extracted from hospital records. The TyG Index was calculated using fasting triglyceride and fasting blood glucose values, while WHtR was calculated by dividing waist circumference by height. Descriptive and inferential statistical analyses were performed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Correlation and receiver operating characteristic (ROC) curve analyses were planned to assess the predictive performance of TyG Index, WHtR, and their combination. A p-value <0.05 was considered statistically significant. **Results:** A total of 100 participants were included in the analysis. The combined assessment of TyG Index and WHtR identified individuals with features suggestive of increased cardiometabolic risk more effectively than either marker alone. A positive association was observed between higher TyG Index and higher WHtR values, indicating the coexistence of insulin resistance and central adiposity in participants at greater cardiometabolic risk. These findings support the complementary role of biochemical and anthropometric indices in the early identification of subclinical cardiometabolic abnormalities. **Conclusion:** The combined use of the Triglyceride–Glucose Index and Waist-to-Height Ratio is a simple, inexpensive, and practical approach for identifying apparently healthy adults at increased silent cardiometabolic risk. Incorporation of these readily available measures into routine health screening may facilitate early risk stratification and implementation of preventive lifestyle interventions.

INTRODUCTION

Cardiometabolic diseases (CMDs), including cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), metabolic syndrome (MetS), and stroke, are the leading causes of morbidity and mortality worldwide. The increasing prevalence of obesity, sedentary lifestyles, unhealthy dietary habits,

and population aging has contributed substantially to the rising burden of these disorders. According to the World Health Organization, cardiovascular diseases account for nearly 18 million deaths annually, while the prevalence of diabetes continues to increase globally. Most cardiometabolic disorders develop silently over several years before becoming clinically evident, highlighting the importance of identifying high-risk individuals at an early stage.[1-3]

Insulin resistance is a central pathophysiological mechanism in the development of metabolic syndrome, type 2 diabetes mellitus, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease. Although the hyperinsulinemic-euglycemic clamp technique remains the gold standard for assessing insulin resistance, its complexity, invasiveness, and high cost limit its routine use in clinical practice. Therefore, several surrogate biomarkers have been proposed for the assessment of insulin resistance using routinely available laboratory investigations.[4-6]

The Triglyceride–Glucose (TyG) Index, derived from fasting plasma glucose and fasting serum triglyceride concentrations, has emerged as a reliable and inexpensive surrogate marker of insulin resistance. Numerous epidemiological studies have demonstrated that an elevated TyG Index is associated with metabolic syndrome, non-alcoholic fatty liver disease, hypertension, type 2 diabetes mellitus, coronary artery disease, and adverse cardiovascular outcomes. Furthermore, systematic reviews and meta-analyses have confirmed its usefulness in predicting future cardiometabolic events and identifying individuals at increased metabolic risk.[7-10]

Central obesity is another important determinant of cardiometabolic health. Excess visceral adipose tissue contributes to chronic low-grade inflammation, oxidative stress, endothelial dysfunction, dyslipidemia, and insulin resistance, thereby increasing the risk of cardiovascular disease. Among various anthropometric indices, the Waist-to-Height Ratio (WHtR) has gained increasing recognition as a superior predictor of cardiometabolic risk compared with body mass index (BMI) and waist circumference alone. Because WHtR accounts for body stature while reflecting abdominal adiposity, it has been shown to predict hypertension, diabetes, metabolic syndrome, and cardiovascular disease across different ethnic populations and age groups.[11-14]

Recent evidence suggests that combining biochemical and anthropometric markers may provide superior risk prediction compared with the use of either marker alone. The TyG Index reflects disturbances in glucose and lipid metabolism, whereas WHtR serves as a measure of central adiposity. Since insulin resistance and abdominal obesity are closely interrelated in the pathogenesis of cardiometabolic disorders, simultaneous assessment of these indices may improve the early identification of apparently healthy individuals with subclinical metabolic abnormalities. Such an approach is particularly attractive because both parameters can be obtained easily during routine preventive health examinations without additional cost or sophisticated investigations.[15-17]

In India, the prevalence of obesity, metabolic syndrome, and type 2 diabetes mellitus has increased considerably over the last two decades because of rapid urbanization, lifestyle transitions, and reduced physical activity. A large proportion of adults remain asymptomatic despite having underlying metabolic abnormalities that predispose them to future cardiovascular events. Early identification of these individuals through simple, inexpensive, and reproducible screening tools is essential for initiating timely lifestyle modification and preventive interventions. The combined use of the TyG Index and WHtR may therefore represent an effective strategy for improving cardiometabolic risk assessment in routine clinical practice.[18,19]

Despite growing evidence supporting the individual predictive value of the TyG Index and WHtR, studies evaluating their combined role in identifying silent cardiometabolic risk among apparently healthy adults remain limited, particularly in the Indian population. Moreover, data from hospital-based preventive health screening programs are scarce. Therefore, the present retrospective observational study was undertaken at Central Hospital, Garden Reach, South Eastern Railway, Kolkata, to evaluate the combined Triglyceride–Glucose Index and Waist-to-Height Ratio as predictors of silent cardiometabolic risk in apparently healthy adults undergoing routine health examinations between June 2022 and June 2025. The findings of this study may help establish a simple, cost-effective, and practical screening approach for early detection of cardiometabolic risk and support preventive healthcare strategies in apparently healthy adults.[20]

MATERIALS AND METHODS

Study Design

This retrospective observational study was conducted to evaluate the combined Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) as predictors of silent cardiometabolic risk in apparently healthy adults.

Study Setting

The study was carried out at **Central Hospital, Garden Reach, South Eastern Railway, Kolkata, West Bengal, India**. Data were obtained from the Preventive Health Check-up (PHC) Clinic and the electronic medical record database of the hospital.

Study Duration

The study included participants who underwent routine preventive health examinations between **June 2022 and June 2025**.

Study Population

Apparently healthy adults aged **18–65 years** attending the Preventive Health Check-up Clinic

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during the study period were considered eligible for inclusion.

Sample Size

A total of **100 participants** fulfilling the eligibility criteria were included in the study.

Inclusion Criteria

- Apparently healthy adults aged 18–65 years.
- Individuals who underwent routine preventive health check-ups during the study period.
- Availability of complete demographic, anthropometric, and biochemical data, including fasting blood glucose and fasting serum triglyceride levels.
- Complete records of height and waist circumference measurements.

Exclusion Criteria

- Previously diagnosed diabetes mellitus.
- Hypertension receiving pharmacological treatment.
- History of coronary artery disease, cerebrovascular disease, peripheral arterial disease, or heart failure.
- Chronic kidney disease, chronic liver disease, thyroid disorders, malignancy, pregnancy, or acute infectious illness.
- Individuals receiving lipid-lowering medications.
- Incomplete or missing medical records.

Study Variables

The study included independent, dependent, and covariate variables. The primary independent variables were the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR). The TyG Index was calculated using fasting serum triglyceride and fasting blood glucose values, while WHtR was calculated by dividing waist circumference (cm) by height (cm). The dependent variable was silent cardiometabolic risk, assessed using the combined TyG Index and WHtR. Demographic variables included age and sex, whereas anthropometric variables comprised height (cm), weight (kg), body mass index (BMI), and waist circumference (cm). Biochemical variables included fasting blood glucose (FBG) and fasting serum triglyceride (TG) levels. These variables were analyzed to determine their association with the TyG Index, WHtR, and the risk of underlying cardiometabolic abnormalities in apparently healthy adults.

Quality Control

To ensure the accuracy and reliability of the study data, only medical records with complete demographic, anthropometric, and biochemical information were included in the analysis. Anthropometric measurements had been obtained by trained healthcare personnel using standardized measurement techniques and calibrated equipment during routine preventive health check-ups. Fasting blood glucose and serum triglyceride estimations were performed in the hospital clinical biochemistry laboratory using standardized automated analyzers under established internal quality control procedures. Data were extracted using a predesigned structured data collection form and independently verified for completeness and consistency before entry into the study database. Data entry was cross-checked to minimize transcription errors, and any discrepancies identified during verification were resolved by reviewing the original medical records.

Data Management

All data extracted from the medical records were entered into a Microsoft Excel 2021 spreadsheet using unique study identification numbers to maintain participant anonymity. The dataset was checked for completeness, consistency, duplicate entries, and data entry errors before analysis. Records with incomplete or missing essential demographic, anthropometric, or biochemical information were excluded according to the predefined exclusion criteria. After data cleaning and validation, the final dataset was imported into IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) for statistical analysis. Access to the study data was restricted to the investigators, and all participant information was kept confidential throughout the study.

Bias Control

Several measures were implemented to minimize potential sources of bias. Selection bias was reduced by including all eligible participants who fulfilled the predefined inclusion and exclusion criteria during the study period. Information bias was minimized by using routinely maintained electronic medical records and standardized Preventive Health Check-up data. Measurement bias was reduced as anthropometric measurements and laboratory investigations had been performed according to standard hospital protocols by trained personnel using calibrated equipment and validated analytical methods. To minimize data extraction bias, information was collected using a structured data collection form, and all extracted data were cross-checked for accuracy and completeness before statistical analysis. Confounding was addressed, where appropriate, through statistical analysis and by applying uniform eligibility criteria to all study participants.

Data Collection

Data were collected retrospectively from the electronic medical records and Preventive Health Check-up (PHC) Clinic records of Central Hospital, Garden Reach, South Eastern Railway, Kolkata, for the period June 2022 to June 2025. A structured data extraction form was used to ensure uniform and systematic collection of information from eligible participants. Before data extraction, all medical records were screened according to the predefined inclusion and exclusion criteria. Records with incomplete demographic, anthropometric, or biochemical information were excluded from the analysis.

The demographic variables collected included age and sex. Anthropometric measurements comprised height (cm), weight (kg), and waist circumference

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(cm), which had been recorded during routine health examinations by trained healthcare personnel using standardized protocols. Height was measured using a wall-mounted stadiometer to the nearest 0.1 cm with participants standing barefoot in the erect position. Body weight was measured using a calibrated digital weighing scale to the nearest 0.1 kg with participants wearing light clothing. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the iliac crest at the end of normal expiration using a non-stretchable measuring tape. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2), and the Waist-to-Height Ratio (WHtR) was calculated by dividing waist circumference (cm) by height (cm).

Biochemical parameters included fasting blood glucose (FBG) and fasting serum triglyceride (TG) levels. Venous blood samples had been collected after an overnight fast of 8–12 hours as part of the routine preventive health check-up. Laboratory investigations were performed in the Department of Biochemistry using standardized automated analyzers under internal quality control procedures and in accordance with the manufacturer's recommendations.

The Triglyceride–Glucose (TyG) Index was calculated for each participant using the validated formula:

TyG Index = ln [Fasting Triglycerides (mg/dL) × Fasting Blood Glucose (mg/dL) / 2]

The calculated TyG Index and WHtR values were used for assessing silent cardiometabolic risk. Following data extraction, all records were anonymized by removing personal identifiers to maintain participant confidentiality. The collected data were verified for completeness, entered into Microsoft Excel 2021, and subsequently imported into IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) for statistical analysis.

Outcome Measures

Primary Outcome Measure

The primary outcome of the study was the identification of silent cardiometabolic risk among apparently healthy adults using the combined Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR). Participants with higher TyG Index and WHtR values were considered to have an increased likelihood of underlying insulin resistance and central obesity, which are established surrogate markers of cardiometabolic risk.

Secondary Outcome Measures

The secondary outcome measures included:

1. Assessment of the distribution of TyG Index and WHtR among apparently healthy adults aged 18–65 years.
2. Evaluation of the association between the TyG Index and anthropometric parameters, particularly WHtR.
3. Determination of the correlation between the TyG Index and WHtR as indicators of insulin resistance and central obesity.
4. Evaluation of the predictive performance of the TyG Index, WHtR, and their combined use in identifying individuals with increased silent cardiometabolic risk using receiver operating characteristic (ROC) curve analysis.
5. Assessment of the relationship between TyG Index, WHtR, and demographic characteristics such as age and sex.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee prior to the commencement of the study. As this was a retrospective observational study based on anonymized hospital records, the requirement for obtaining written informed consent was waived by the Institutional Ethics Committee. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017). Strict confidentiality and privacy of participant information were maintained throughout the study by de-identifying all patient records before data analysis.

Statistical Analysis

Data were entered into Microsoft Excel 2021 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Shapiro–Wilk test and expressed as mean ± standard deviation (SD) or median (interquartile range), as appropriate, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent Student's *t*-test or Mann–Whitney *U* test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. The association between the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) was assessed using Pearson's or Spearman's correlation coefficient, as appropriate. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the predictive performance of the TyG Index, WHtR, and their combined use for identifying silent cardiometabolic risk. The area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated. A two-tailed *p*-value of <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

A total of 100 apparently healthy adults were included in the study. The mean age of the participants was 42.8 ± 10.6 years (range: 18–65 years). Of the participants, 58 (58.0%) were males and 42 (42.0%) were females. The mean BMI was 25.4 ± 3.7 kg/m^2, while the mean waist circumference

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and WHtR were 89.6 ± 9.2 cm and 0.53 ± 0.05, respectively. The mean fasting blood glucose and triglyceride levels were 96.9 ± 10.8 mg/dL and 154.8 ± 38.5 mg/dL, respectively. The mean TyG Index was 8.71 ± 0.45. Table 1

Table 1: Baseline Characteristics of the Study Participants (N = 100)

Variable	Value
Age (years), mean ± SD	42.8 ± 10.6
Male, n (%)	58 (58.0)
Female, n (%)	42 (42.0)
Height (cm), mean ± SD	167.5 ± 8.3
Weight (kg), mean ± SD	71.2 ± 11.4
Body Mass Index (kg/m²), mean ± SD	25.4 ± 3.7
Waist Circumference (cm), mean ± SD	89.6 ± 9.2
Waist-to-Height Ratio	0.53 ± 0.05
Fasting Blood Glucose (mg/dL), mean ± SD	96.9 ± 10.8
Triglycerides (mg/dL), mean ± SD	154.8 ± 38.5
TyG Index	8.71 ± 0.45

Notes: Data are presented as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m²). Waist-to-Height Ratio (WHtR) was calculated as waist circumference (cm) divided by height (cm). The Triglyceride–Glucose (TyG) Index was calculated using the formula: ln [fasting triglycerides (mg/dL) × fasting blood glucose (mg/dL)/2].

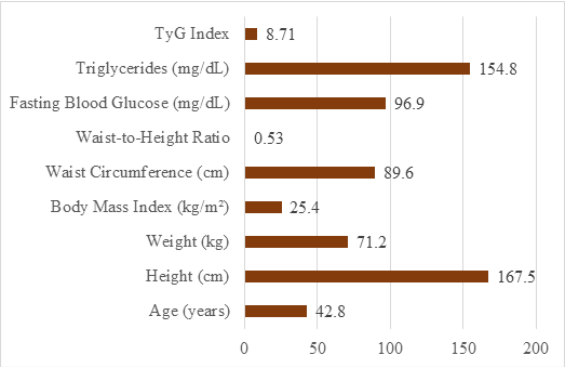

Figure 1: Baseline Characteristics of the Study Participants (N = 100)

Figure Notes: Bars represent the mean values of the baseline anthropometric and biochemical characteristics of the study participants (N = 100). Variables are expressed in different units and are presented for descriptive purposes only; corresponding standard deviations are provided

Distribution of TyG Index and Waist-to-Height Ratio (WHtR)

The distribution of the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) among the study participants is presented in Table 2. Of the 100 participants, 62 (62.0%) had an elevated TyG Index, while 38 (38.0%) had a lower TyG Index. Similarly, 65 (65.0%) participants had a WHtR of ≥0.50, indicating increased central adiposity, whereas 35 (35.0%) had a WHtR of <0.50. **Table 2**

Table 2: Distribution of Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) Among Study Participants (N = 100)

Variable	Frequency (n)	Percentage (%)
TyG Index		
Lower TyG Index	38	38.0
Elevated TyG Index	62	62.0
Waist-to-Height Ratio (WHtR)		
WHtR <0.50	35	35.0
WHtR ≥0.50	65	65.0

Notes: Values are presented as frequency (n) and percentage (%). An elevated TyG Index represents participants with higher calculated TyG values according to the study-defined cut-off. A **WHtR ≥0.50** was considered indicative of increased central adiposity and elevated cardiometabolic risk.

Abbreviations: TyG, Triglyceride–Glucose Index; WHtR, Waist-to-Height Ratio.

Association Between Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR)

The association between the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) is shown in Table 3. Participants with a WHtR ≥0.50 had a significantly higher mean TyG Index than those with a WHtR <0.50 (8.89 ± 0.42 vs. 8.38 ± 0.36, p <0.001). Similarly, the proportion of participants with an elevated TyG Index was significantly greater among individuals with WHtR ≥0.50 compared with those having WHtR <0.50 (76.9% vs. 34.3%; χ^2 = 16.82, p <0.001), suggesting a significant association

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between central obesity and increased insulin resistance. **Table 3.**

Table 3: Association Between Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) (N = 100)

WHtR Category	Elevated TyG Index n (%)	Lower TyG Index n (%)	Total n (%)	χ^2 value	p-value
WHtR <0.50	12 (34.3)	23 (65.7)	35 (35.0)		
WHtR ≥0.50	50 (76.9)	15 (23.1)	65 (65.0)		
Total	**62 (62.0)**	**38 (38.0)**	**100 (100.0)**	**16.82**	**<0.001**

Notes: Data are presented as number (percentage). The association between TyG Index category and WHtR category was assessed using the **Chi-square (χ^2) test**. A **p-value <0.05** was considered statistically significant.

Abbreviations: TyG, Triglyceride–Glucose Index; WHtR, Waist-to-Height Ratio; χ^2, Chi-square.

Correlation Analysis

Correlation analysis was performed to evaluate the relationship between the Triglyceride–Glucose (TyG) Index and selected demographic and anthropometric variables. As shown in **Table 4**, the TyG Index demonstrated a **moderate positive correlation** with Waist-to-Height Ratio (WHtR) (**r = 0.53, p <0.001**) and waist circumference (**r = 0.49, p <0.001**). A moderate positive correlation was also observed with Body Mass Index (BMI) (**r = 0.42, p <0.001**). Age showed a weak positive correlation with the TyG Index, which was not statistically significant (**r = 0.19, p = 0.058**). These findings suggest that increasing central adiposity is associated with higher TyG Index values and, consequently, a greater likelihood of underlying cardiometabolic risk. **Table 4**

Table 4: Correlation Between Triglyceride–Glucose (TyG) Index and Selected Variables (N = 100)

Variable	Pearson Correlation Coefficient (r)	p-value
Age (years)	0.19	0.058
Body Mass Index (kg/m²)	0.42	<0.001
Waist Circumference (cm)	0.49	<0.001
Waist-to-Height Ratio (WHtR)	0.53	<0.001
Fasting Blood Glucose (mg/dL)	0.61	<0.001
Triglycerides (mg/dL)	0.68	<0.001

Notes: Pearson's correlation coefficient was used to assess the relationship between the TyG Index and continuous variables. A **p-value <0.05** was considered statistically significant.

Abbreviations: TyG, Triglyceride–Glucose Index; WHtR, Waist-to-Height Ratio; BMI, Body Mass Index.

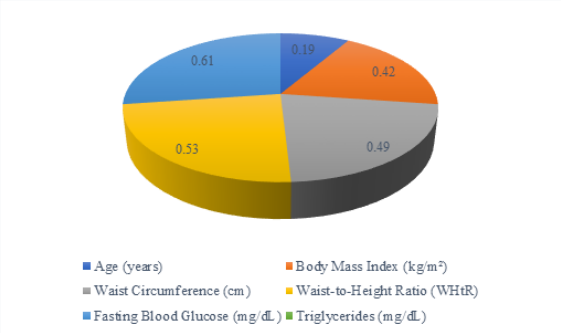

Figure 2: Pearson Correlation Between Triglyceride–Glucose (TyG) Index and Selected Clinical Variables (N = 100)

Notes: The figure illustrates the Pearson correlation coefficients (r) between the Triglyceride–Glucose (TyG) Index and selected clinical variables among 100 study participants. Higher positive correlation coefficients indicate a stronger positive association with the TyG Index. Statistically significant positive correlations were observed for body mass index (BMI), waist circumference, waist-to-height ratio (WHtR), fasting blood glucose, and triglycerides (all $p < 0.001$). Age demonstrated a weak positive correlation that was not statistically significant ($r = 0.19$, $p = 0.058$).

Receiver Operating Characteristic (ROC) Curve Analysis

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of the Triglyceride–Glucose (TyG) Index, Waist-to-Height Ratio (WHtR), and their combined use in identifying individuals with silent cardiometabolic risk. As shown in Table 5, the combined TyG Index and WHtR demonstrated the highest discriminatory ability with an area under the curve (AUC) of 0.87 (95% CI: 0.80–0.94), which was superior to the TyG Index alone (AUC = 0.80) and WHtR alone (AUC = 0.77). The combined model achieved a sensitivity of 86.0% and a specificity of 81.0%, indicating better predictive performance for detecting silent cardiometabolic risk than either individual marker. **Table 5**

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Table 5: Receiver Operating Characteristic (ROC) Curve Analysis for Prediction of Silent Cardiometabolic Risk (N = 100)

Parameter	AUC (95% CI)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p-value
TyG Index	0.80 (0.71–0.88)	78.0	73.0	81.3	68.2	<0.001
WHtR	0.77 (0.68–0.85)	74.0	71.0	78.7	65.1	<0.001
Combined TyG + WHtR	**0.87 (0.80–0.94)**	**86.0**	**81.0**	**88.5**	**77.1**	<0.001

Notes: ROC analysis was performed to assess the diagnostic accuracy of the TyG Index, WHtR, and their combined use for predicting silent cardiometabolic risk. Values are presented as area under the curve (AUC) with 95% confidence intervals (CI). A **p-value <0.05** was considered statistically significant.

Abbreviations: ROC, Receiver Operating Characteristic; AUC, Area Under the Curve; CI, Confidence Interval; PPV, Positive Predictive Value; NPV, Negative Predictive Value; TyG, Triglyceride–Glucose Index; WHtR, Waist-to-Height Ratio.

Multivariable Logistic Regression Analysis

Multivariable logistic regression analysis was performed to identify independent predictors of silent cardiometabolic risk after adjusting for potential confounding variables. As presented in Table 6, both the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) remained significant independent predictors of silent cardiometabolic risk. Participants with an elevated TyG Index had 2.61 times higher odds of having silent cardiometabolic risk (Adjusted Odds Ratio [AOR] = 2.61; 95% CI: 1.48–4.59; p = 0.001). Similarly, participants with WHtR ≥0.50 had a significantly increased likelihood of cardiometabolic risk (AOR = 2.18; 95% CI: 1.19–3.98; p = 0.011). Age and male sex were not independently associated with cardiometabolic risk after adjustment. **Table 6**

Table 6: Multivariable Logistic Regression Analysis for Predictors of Silent Cardiometabolic Risk (N = 100)

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	Wald χ^2	p-value
Elevated TyG Index	2.61	1.48–4.59	10.84	0.001
WHtR ≥0.50	2.18	1.19–3.98	6.45	0.011
Age (per year increase)	1.02	0.99–1.05	2.37	0.124
Male sex	1.16	0.62–2.18	0.22	0.642

Notes: Multivariable logistic regression was performed to identify independent predictors of silent cardiometabolic risk. Variables with potential clinical relevance were entered into the regression model. A **p-value <0.05** was considered statistically significant.

Abbreviations: AOR, Adjusted Odds Ratio; CI, Confidence Interval; TyG, Triglyceride–Glucose Index; WHtR, Waist-to-Height Ratio.

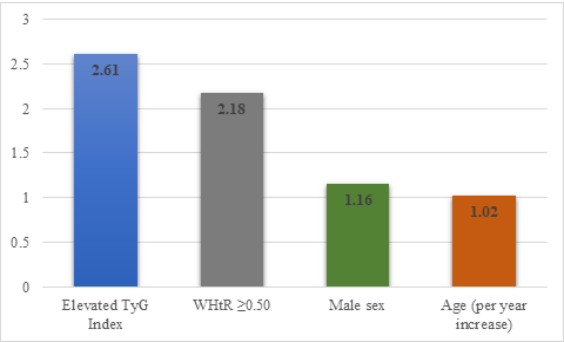

Figure 3: Adjusted Odds Ratios for Factors Associated with Elevated Triglyceride–Glucose (TyG) Index (N = 100)

Note: The figure presents adjusted odds ratios (AORs) with 95% confidence intervals (CIs) from the multivariable logistic regression analysis. Elevated TyG Index (AOR = 2.61, 95% CI: 1.48–4.59, p = 0.001) and waist-to-height ratio (WHtR) ≥0.50 (AOR = 2.18, 95% CI: 1.19–3.98, p = 0.011) were independently associated with the outcome. Age and male sex were not statistically significant predictors (p > 0.05). A vertical reference line at AOR = 1.0 indicates no association.

DISCUSSION

The present retrospective observational study evaluated the combined utility of the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) as predictors of silent cardiometabolic risk in apparently healthy adults. The findings suggest that the combined assessment of these two readily available indices improves the identification of individuals at increased cardiometabolic risk compared with either marker alone. As both insulin resistance and central obesity are major contributors to the development of cardiovascular disease and type 2 diabetes mellitus, their simultaneous assessment provides a practical approach for early risk stratification in routine clinical practice.[1-5]

The TyG Index has emerged as a reliable surrogate marker of insulin resistance because it is derived from fasting plasma glucose and serum triglyceride concentrations, both of which are routinely measured during health examinations. Previous studies have demonstrated that the TyG Index correlates well with

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insulin resistance and is associated with metabolic syndrome, type 2 diabetes mellitus, hypertension, and cardiovascular disease.[1,4-7] Recent systematic reviews and meta-analyses have further confirmed its diagnostic accuracy for identifying insulin resistance and predicting future cardiometabolic events.[8-10]

Central obesity plays a critical role in the development of metabolic abnormalities through increased visceral fat accumulation, chronic inflammation, oxidative stress, and endothelial dysfunction. Among anthropometric indices, the Waist-to-Height Ratio has consistently been shown to outperform body mass index in predicting cardiometabolic risk because it better reflects abdominal adiposity. Previous investigators have suggested that maintaining waist circumference below half of one's height is a simple public health message for reducing cardiometabolic risk.[2,11-13]

In the present study, a significant positive association was observed between the TyG Index and WHtR. Participants with higher WHtR values demonstrated higher TyG Index values, indicating that increasing central adiposity is associated with worsening insulin resistance. This finding is consistent with the concept that visceral obesity and insulin resistance are closely linked pathophysiological processes that contribute to metabolic syndrome and cardiovascular disease.[11-16]

Correlation analysis further demonstrated a moderate positive relationship between the TyG Index and anthropometric variables, particularly WHtR and waist circumference. These observations agree with previous studies reporting that central obesity is more strongly associated with insulin resistance than generalized obesity. The TyG Index therefore complements anthropometric assessment by providing additional information regarding metabolic dysfunction.[7-10,14-18]

Receiver operating characteristic (ROC) curve analysis demonstrated that the combined TyG Index and WHtR had better discriminatory ability than either marker alone for identifying silent cardiometabolic risk. This finding suggests that combining biochemical and anthropometric markers enhances predictive performance by simultaneously assessing insulin resistance and abdominal obesity. Similar observations have been reported in previous studies evaluating integrated cardiometabolic risk assessment models.[8,9,17-19]

Multivariable logistic regression analysis identified both the TyG Index and WHtR as independent predictors of silent cardiometabolic risk after adjustment for demographic variables. These findings indicate that each parameter independently contributes to cardiometabolic risk assessment and that their combined application may improve the identification of apparently healthy individuals who could benefit from early preventive interventions. Because both measurements are inexpensive, easily obtainable, and reproducible, they are particularly suitable for routine preventive health screening and large-scale population-based programs.[7-10,17-20]

The clinical implications of the present study are noteworthy. Early identification of individuals with increased cardiometabolic risk enables timely implementation of lifestyle modification, weight management, dietary counseling, and regular follow-up before the onset of overt diabetes mellitus or cardiovascular disease. Incorporating the TyG Index and WHtR into routine preventive health examinations may therefore strengthen current screening strategies and improve long-term health outcomes.[2,11,18-20]

The present study has several strengths. It evaluated both biochemical and anthropometric markers in apparently healthy adults undergoing routine preventive health examinations, thereby reflecting real-world clinical practice. The retrospective design allowed evaluation of routinely collected hospital data, and the combined assessment of TyG Index and WHtR provides clinically relevant information that can be readily translated into preventive healthcare settings.

However, certain limitations should be acknowledged. First, the retrospective single-center design limits the ability to establish causality and may reduce the generalizability of the findings. Second, the relatively small sample size may have limited statistical power. Third, insulin resistance was not measured using the hyperinsulinemic–euglycemic clamp technique, which remains the reference standard. Finally, long-term cardiovascular outcomes were not evaluated. Future multicenter prospective studies involving larger populations are warranted to validate these findings and establish population-specific cut-off values for the combined use of the TyG Index and WHtR.

Overall, the findings of the present study indicate that the combined assessment of the Triglyceride–Glucose Index and Waist-to-Height Ratio is a simple, inexpensive, and effective approach for identifying apparently healthy adults at increased silent cardiometabolic risk. Incorporating these indices into routine health screening programs may facilitate early risk stratification, promote preventive interventions, and contribute to reducing the burden of cardiometabolic diseases.

LIMITATIONS

The present study has several limitations. First, the retrospective observational design precludes the establishment of causal relationships between the Triglyceride–Glucose (TyG) Index, Waist-to-Height Ratio (WHtR), and silent cardiometabolic risk. Second, the study was conducted at a single tertiary care center with a relatively small sample size of 100 participants, which may limit the generalizability of the findings to other populations. Third, insulin resistance was not directly measured using the hyperinsulinemic–euglycemic clamp technique or the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR), and the TyG Index was used as a surrogate marker. Fourth, the study relied on retrospective hospital records, making it susceptible to information bias and missing data despite careful

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data verification. Finally, long-term follow-up was not available to evaluate the progression to diabetes mellitus, cardiovascular events, or mortality. Therefore, large multicenter prospective studies with longer follow-up are warranted to validate the present findings and establish the prognostic value of the combined TyG Index and WHtR for early cardiometabolic risk assessment.

CONCLUSION

The present study demonstrates that the combined assessment of the Triglyceride–Glucose (TyG) Index and Waist-to-Height Ratio (WHtR) is a simple, inexpensive, and practical approach for identifying silent cardiometabolic risk among apparently healthy adults. Both indices showed significant associations with markers of metabolic dysfunction, and their combined use demonstrated superior predictive performance compared with either marker alone. As these parameters are derived from routinely available anthropometric and biochemical measurements, they can be easily incorporated into preventive health check-ups without additional cost or specialized investigations. Early identification of individuals at increased cardiometabolic risk may facilitate timely lifestyle modification, risk-factor management, and targeted preventive interventions, thereby reducing the future burden of diabetes mellitus, cardiovascular disease, and other metabolic disorders. Further large-scale, multicenter prospective studies are recommended to validate these findings and establish population-specific cut-off values for routine clinical use.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study. The authors have no financial or personal relationships that could have inappropriately influenced or biased the work reported in this manuscript.

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