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Association between the triglyceride-glucose index and waist circumference with electrocardiogram ST-T changes: a cross-sectional study

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Abstract

Background

Electrocardiogram (ECG) ST-T changes are early, important manifestations of myocardial ischemia and are closely associated with cardiovascular disease risk. The triglyceride-glucose-waist circumference index (TyG-WC), a composite marker of insulin resistance and metabolic syndrome, has an unclear relationship with ECG ST-T changes. This study aimed to investigate the association between TyG-WC and ECG ST-T changes in an older adult population.

Methods

This cross-sectional study included 15,966 older adults who underwent comprehensive health examinations. Restricted cubic spline (RCS) regression was used to fit the dose-response relationship between TyG-WC and ST-T changes. Univariable and multivariable logistic regression analyses were performed to evaluate the strength of the association. Receiver operating characteristic (ROC) curve and decision curve analyses were used to assess model performance. The study was approved by the Ethics Committee of Nanchong Gaoping District People's Hospital and all participants provided written informed consent.

Results

The mean age of participants was 73.5 ± 7.0 years, and 46.5% (n = 7,426) were male. The prevalence of ST-T abnormalities was 25.1% (n = 4,012). After multivariable adjustment, each one-unit increase in TyG-WC was associated with a 0.5% increase in the odds of ST-T changes (adjusted OR = 1.005, 95% CI 1.004–1.006, P < 0.001). RCS analysis revealed a linear positive association between TyG-WC and ST-T changes (P overall = 0.001, P non-linearity = 0.318). TyG-WC showed a modest but statistically superior discriminative ability compared with TyG alone (AUC 0.576 vs. 0.569; DeLong P < 0.001).

Conclusions

TyG-WC was independently, linearly associated with ECG ST-T changes in older adults, showing superior discriminative ability compared with TyG alone. TyG-WC may serve as a simple screening tool for identifying individuals at high risk of subclinical myocardial ischemia.

Trial registration

Not applicable (observational study).

Background

Electrocardiogram ST-T abnormalities, including ST-segment depression and T-wave inversion or flattening, are among the most common ECG findings in routine health examinations and clinical practice. These abnormalities are markers of myocardial repolarization heterogeneity and may indicate subclinical myocardial ischemia, left ventricular hypertrophy, or electrolyte disturbances. In population-based studies, the prevalence of ST-T abnormalities ranges from 5% to 30% depending on age, sex, and study population, and has been consistently associated with an increased risk of coronary heart disease, heart failure, and cardiovascular mortality [1]. Identifying modifiable risk factors associated with ST-T abnormalities is therefore of great importance for the early prevention of adverse cardiovascular outcomes.

Insulin resistance (IR) is a core pathophysiological mechanism underlying metabolic syndrome and cardiovascular disease. The triglyceride-glucose (TyG) index, calculated as ln[fasting triglycerides (mg/dL) × fasting glucose (mg/dL)/2], has been extensively validated as a reliable surrogate marker of IR. In recent years, the TyG index has been established as an independent predictor of cardiovascular events [2]. However, the TyG index alone does not account for obesity, which is a major risk factor for cardiovascular disease.

Waist circumference (WC) is a simple indicator of abdominal obesity and is closely correlated with visceral fat accumulation. Combining the TyG index with WC to form the TyG-waist circumference index (TyG-WC) may provide a more comprehensive reflection of cardiometabolic risk. Fan et al. [3] demonstrated in a prospective cohort study that the TyG index and its obesity-related derivatives, including TyG-WC, were significantly associated with cardiac structure and function.

However, no study to date has directly investigated the association between the TyG-WC index and ECG ST-T changes in older adults. Therefore, the present study aimed to: (1) evaluate the association between TyG-WC and ECG ST-T changes in an older adult population; (2) compare the discriminative ability of TyG-WC and TyG alone; and (3) explore the dose-response relationship using RCS analysis.

Methods

Study design and participants

This was a cross-sectional study based on data from a community health examination database. A total of 15,966 middle-aged and older adults who completed comprehensive health assessments (including ECG, anthropometric measurements, and laboratory tests) were enrolled. Individuals with missing data on key variables were excluded. The study was approved by the Ethics Committee of Nanchong Gaoping District People's Hospital, Sichuan, and written informed consent was obtained from all participants.

Data collection

Demographic information (age, sex), anthropometric measurements (height, weight, waist circumference, blood pressure), laboratory tests (fasting glucose, triglycerides, total cholesterol, HDL-C, LDL-C, serum creatinine, blood urea nitrogen, complete blood count), and ECG recordings were collected. Waist circumference was measured at the midpoint between the lower rib margin and the iliac crest. Blood samples were collected after at least 8 hours of fasting. Standard 12-lead ECG was recorded in the resting state.

Variable definitions

TyG index = ln[fasting triglycerides (mg/dL) × fasting glucose (mg/dL)/2]. TyG-waist circumference index (TyG-WC) = TyG index × waist circumference (cm). ST-T abnormality was defined as ST-segment depression ≥ 0.05 mV or T-wave inversion ≥ 0.1 mV in at least two consecutive leads. Hypertension was defined as systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or current use of antihypertensive medication. Diabetes was defined as fasting glucose ≥ 7.0 mmol/L or current use of glucose-lowering medication. BMI = weight (kg)/height (m)².

Statistical analysis

Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies (percentages). Group comparisons were performed using the t test, Mann-Whitney U test, or χ^2 test, as appropriate. Univariable and multivariable logistic regression analyses were used to evaluate the association between TyG-WC and ST-T abnormalities, with odds ratios (ORs) and 95% confidence intervals (CIs) calculated. Covariates were selected based on prior literature and clinical judgment. ROC curves were used to evaluate discriminative ability; the Youden index was used to determine the optimal cutoff value, and the DeLong test was used to compare AUC values. The net reclassification improvement (NRI) and integrated discrimination improvement (IDI) were calculated. The clinical utility of the model was assessed using decision curve analysis [4]. RCS regression with three knots was used to examine the dose-response relationship. Two-tailed $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics of participants

A total of 15,966 participants were included, with a mean age of 73.5 ± 7.0 years; 7,426 (46.5%) were male. The overall prevalence of ST-T abnormalities was 25.1% (n = 4,012). Compared with the normal ST-T group, the abnormal group was older (74.4 ± 7.2 vs. 73.1 ± 6.9 years), had a higher proportion of females (66.8% vs. 49.0%), and exhibited larger waist circumference (83.8 ± 9.1 vs. 81.7 ± 8.9 cm). Systolic blood pressure, diastolic blood pressure, fasting glucose, TyG, and TyG-WC were significantly higher, while HDL-C was significantly lower in the abnormal group (all $P < 0.001$). The prevalence of hypertension (50.3% vs. 39.3%) and diabetes (13.1% vs. 10.7%) were also significantly higher in the abnormal group (Table 1).

Table 1

Baseline characteristics of participants. Continuous variables are expressed as mean ± standard deviation; categorical variables as percentages. BMI: body mass index; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TyG: triglyceride-glucose index; TyG-WC: TyG-waist circumference index; SBP: systolic blood pressure; DBP: diastolic blood pressure; FBG: fasting blood glucose; TC: total cholesterol; Scr: serum creatinine; BUN: blood urea nitrogen.

Variable	Normal ST-T group (n = 11,954)	Abnormal ST-T group (n = 4,012)	P value
Age (years)	73.1 ± 6.9	74.4 ± 7.2	< 0.001
Female (%)	49.0	66.8	< 0.001
Height (cm)	152.2 ± 8.4	150.2 ± 8.1	< 0.001
Weight (kg)	55.4 ± 10.1	55.9 ± 10.1	0.006
Waist circumference (cm)	81.7 ± 8.9	83.8 ± 9.1	< 0.001
BMI (kg/m²)	23.8 ± 3.6	24.7 ± 3.8	< 0.001
SBP (mmHg)	149.0 ± 23.0	152.6 ± 24.6	< 0.001
DBP (mmHg)	79.1 ± 12.9	80.1 ± 13.6	< 0.001
FBG (mmol/L)	6.9 ± 2.8	7.6 ± 3.3	< 0.001
TC (mmol/L)	5.2 ± 1.5	5.3 ± 1.5	< 0.001
HDL-C (mmol/L)	1.38 ± 0.39	1.35 ± 0.37	0.001
LDL-C (mmol/L)	1.33 ± 0.63	1.40 ± 0.66	< 0.001
Scr (μmol/L)	69.7 ± 27.0	71.5 ± 25.2	< 0.001
BUN (mmol/L)	5.9 ± 2.0	6.0 ± 2.1	< 0.001
TyG index	1.27 ± 0.74	1.43 ± 0.75	< 0.001
TyG-WC	105.8 ± 66.0	122.5 ± 68.8	< 0.001
Hypertension (%)	39.3	50.3	< 0.001

Variable	Normal ST-T group (n = 11,954)	Abnormal ST-T group (n = 4,012)	P value
Diabetes (%)	10.7	13.1	< 0.001

Association of TyG-WC with ST-T changes

Univariable logistic regression showed that TyG-WC was significantly associated with ST-T abnormalities (crude OR = 1.005, 95% CI 1.004–1.006, P < 0.001). After full multivariable adjustment, this association remained statistically significant (adjusted OR = 1.005, 95% CI 1.004–1.006, P < 0.001) (Table 2). Female sex was the strongest risk predictor.

Table 2
Multivariable logistic regression analysis of TyG-WC and ST-T changes. Model 5 was adjusted for age, sex, BMI, waist circumference, blood pressure, fasting glucose, lipid profile, serum creatinine, blood urea nitrogen, and white blood cell count.

Model	Adjusted covariates	OR (95% CI)	P value
Model 1	Univariable analysis (TyG-WC only)	1.005 (1.004–1.006)	< 0.001
Model 2	Model 1 + age, sex	1.004 (1.003–1.005)	< 0.001
Model 3	Model 2 + BMI, waist circumference, blood pressure	1.004 (1.003–1.005)	< 0.001
Model 4	Model 3 + fasting blood glucose, blood lipids, renal function	1.005 (1.003–1.006)	< 0.001
Model 5	Fully adjusted model (all above covariates)	1.005 (1.004–1.006)	< 0.001

Dose-response relationship

Restricted cubic spline regression analysis revealed a statistically significant overall association between TyG-WC and ST-T changes ($\chi^2 = 17.02$, P = 0.0007), with a nonlinearity P value of 0.318, indicating an approximately linear positive association. As TyG-WC levels increased, the predicted probability of ST-T changes gradually increased, with no apparent threshold or saturation effect. The model was adjusted for the covariates shown in Fig. 1.

ROC curve analysis and model comparison

ROC curve analysis demonstrated that TyG-WC (AUC = 0.576, 95% CI 0.565–0.587) outperformed the TyG index alone (AUC = 0.569, 95% CI 0.558–0.580; DeLong P < 0.001). The optimal cutoff value was

122.31, with a sensitivity of 0.451 and a specificity of 0.664. The full model incorporating traditional risk factors yielded an AUC of 0.657 (95% CI 0.648–0.667). The continuous NRI was 0.072 (P = 0.0001) and the IDI was 0.002 (P < 0.0001) (Fig. 2, Table 3).

Table 3
Comparison of ROC curves across prediction models. The full model included age, sex, BMI, hypertension, diabetes, lipid profile, and other covariates. DeLong test: TyG-WC vs. TyG, P < 0.001.

Model	AUC (95% CI)	P value
TyG alone	0.569 (0.559–0.580)	< 0.001
TyG-WC	0.576 (0.565–0.586)	< 0.001
TyG-WC + TyG	0.582 (0.571–0.592)	< 0.001
Full model	0.657 (0.648–0.667)	< 0.001

Discussion

Principal findings

In this large cross-sectional study of 15,966 older adults, we demonstrated that the TyG-WC index was independently and linearly associated with ECG ST-T abnormalities. This association remained robust after comprehensive adjustment for potential confounders and was validated through logistic regression, RCS regression, and decision curve analysis. TyG-WC exhibited superior discriminative ability compared with TyG alone. These findings suggest that TyG-WC may serve as a clinically useful screening tool for identifying the risk of ST-T abnormalities in older adults.

Comparison with previous studies

Previous studies have established associations between the TyG index and various ECG abnormalities. Lee et al. [5] reported that the TyG index was independently associated with QTc interval prolongation. Cedres and colleagues [1] demonstrated in the Chicago epidemiologic studies that ECG abnormalities independently predicted coronary heart disease mortality. Fan et al. [3] confirmed that the TyG index and its obesity-related derivatives, including TyG-WC, were significantly associated with cardiac structure and function. Liu et al. [6] reported a U-shaped association between the TyG index and incident atrial fibrillation. Li et al. [7] found that the TyG index was associated with an increased risk of adverse events in patients with atrial fibrillation. Lai et al. [8], using the NHANES database, confirmed that a high TyG index significantly increased cardiovascular disease mortality. Yin et al. [9] demonstrated in the Chinese Kailuan cohort that the TyG index was independently associated with the risk of major adverse cardiovascular events in patients with atrial fibrillation. The present study is the first to specifically investigate the association between TyG-WC and ST-T abnormalities in older adults.

Potential mechanisms

The mechanisms underlying the association between TyG-WC and ST-T abnormalities are likely multifactorial. First, insulin resistance can promote systemic inflammation, oxidative stress, and endothelial dysfunction, compromising coronary microcirculation and leading to myocardial ischemia [10]. Second, abdominal obesity is associated with increased production of pro-inflammatory cytokines, which may directly affect myocardial repolarization [11]. Wang et al. [12] demonstrated that P-wave dispersion was independently associated with insulin resistance. Third, insulin resistance is linked to ion channel dysfunction in cardiomyocytes, potentially increasing susceptibility to repolarization abnormalities [13].

Implications of the dose-response relationship

The linear relationship identified by RCS analysis (P non-linearity = 0.318) suggests that the effect of insulin resistance on myocardial repolarization operates along a continuous gradient without a threshold effect, further supporting the clinical value of TyG-WC as a continuous risk marker.

Clinical implications

TyG-WC, as a simple and inexpensive index, can be used for preliminary cardiovascular risk screening in older adults. Attention should be paid to TyG-WC levels in the management of hypertension.

Strengths and limitations

Strengths include the large sample size, comprehensive adjustment for confounders, and validation through multiple analytical methods, including LASSO regression variable selection [14]. Limitations include: (1) the cross-sectional design precludes causal inference; (2) the single-center older adult population limits generalizability; (3) ST-T abnormalities were based on a single measurement; (4) unmeasured confounding factors may exist; and (5) the AUC of TyG-WC alone was moderate (0.576), and thus it should be used as a component of comprehensive risk assessment rather than an independent diagnostic tool.

Conclusions

This large cross-sectional study confirmed that TyG-WC was independently and linearly associated with ECG ST-T abnormalities in older adults, demonstrating superior discriminative ability compared with TyG alone. TyG-WC may serve as a simple screening tool for identifying older adults at high risk of subclinical myocardial ischemia. Prospective studies are warranted to validate these findings.

Abbreviations

AUC
area under the curve
BMI
body mass index
BUN

blood urea nitrogen
CI
confidence interval
DBP
diastolic blood pressure
ECG
electrocardiogram
FBG
fasting blood glucose
HDL-C
high-density lipoprotein cholesterol
IDI
integrated discrimination improvement
IR
insulin resistance
LDL-C
low-density lipoprotein cholesterol
NRI
net reclassification improvement
OR
odds ratio
RCS
restricted cubic spline
ROC
receiver operating characteristic
SBP
systolic blood pressure
Scr
serum creatinine
TC
total cholesterol
TyG
triglyceride-glucose index
TyG-WC
TyG-waist circumference index
WC
waist circumference.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of Nanchong Gaoping District People's Hospital, Sichuan, China (approval reference number to be confirmed). Written informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

XRL contributed to the study conception and design, performed the data analysis, and critically revised the manuscript. YF contributed to data collection and interpretation, and critically revised the manuscript. YXL contributed to the study conception and design and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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Authors' information

Not applicable.

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Figures

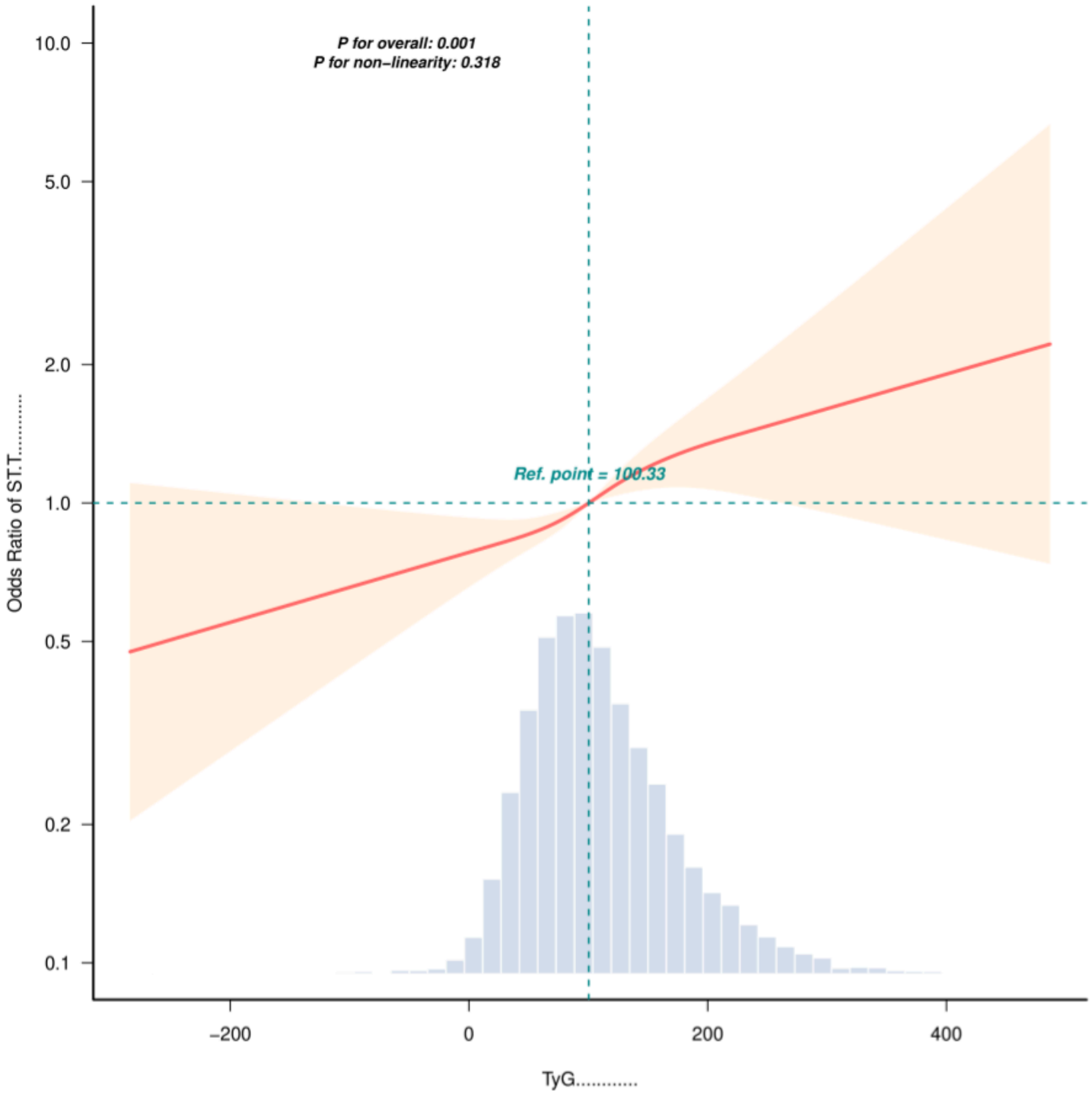


Figure 1

Restricted cubic spline (RCS) fitting curve illustrating the dose-response relationship between TyG-WC and the probability of ST-T changes. The model was adjusted for sex (reference: female), age (73 years), waist circumference (82 cm), BMI (23.79 kg/m²), serum creatinine (66.45 μmol/L), blood urea nitrogen (5.69 mmol/L), HDL-C (1.36 mmol/L), LDL-C (1.25 mmol/L), triglycerides (1.08 mmol/L), total cholesterol (5.24 mmol/L), fasting glucose (6.31 mmol/L), and white blood cell count (6.04 × 10⁹/L). P

for overall = 0.001; P for non-linearity = 0.318. The red line represents the estimated odds ratio and the shaded region the 95% confidence interval.

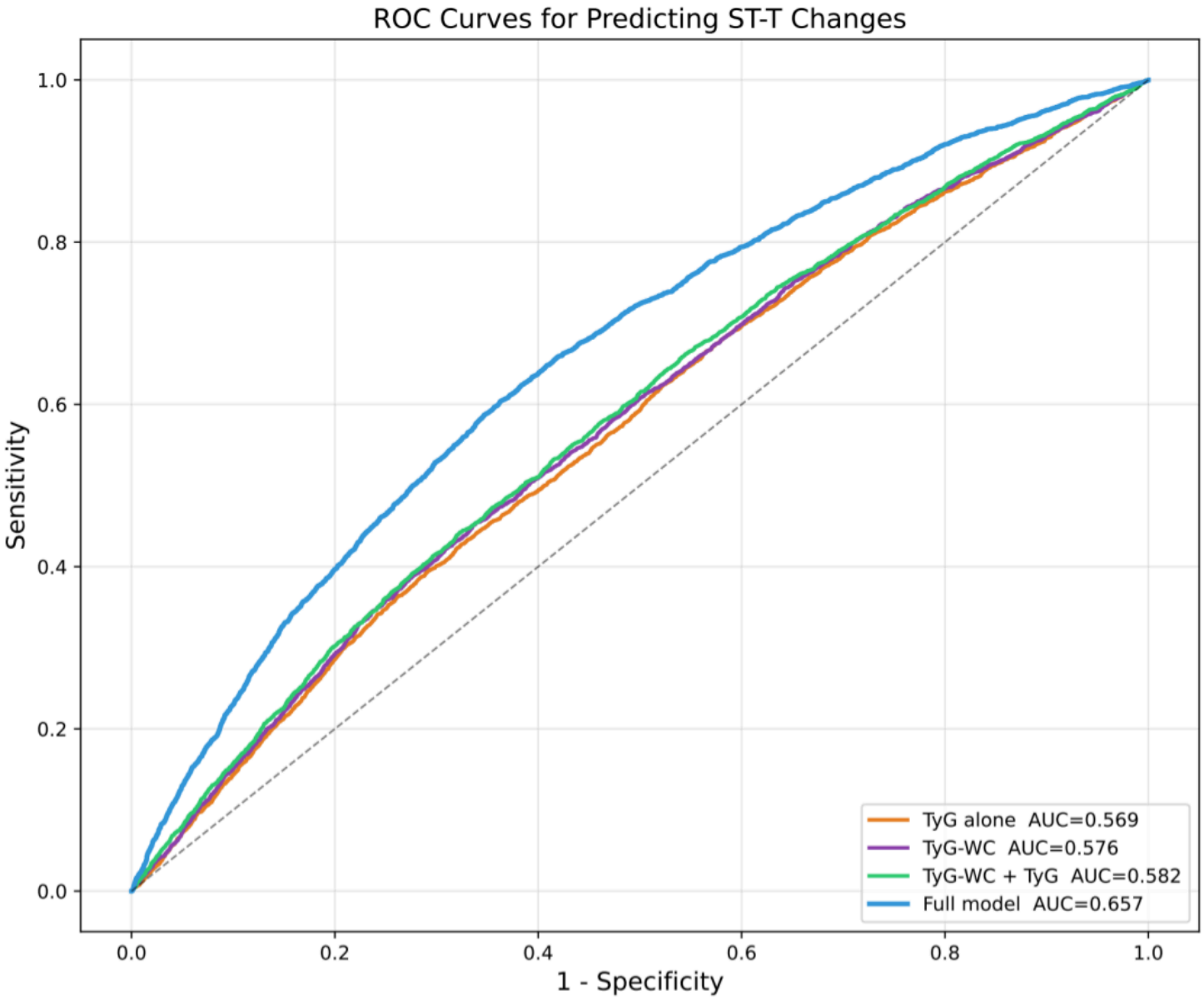


Figure 2

Receiver operating characteristic (ROC) curves of TyG-WC, TyG, and the full model for predicting ST-T changes.

Supplementary Files

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